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Safe Flight 21 Limited Deployment Preliminary Technical Baseline and Cost Briefing Version 4

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Outline

- **Cost Estimate Overview**
- **WBS Overview**
- **Technical Baseline**
- **Cost Results**
- **FAA CIP vs Required F&E Funding**
- **Conclusion**

Cost Estimate Overview

- Purpose:
  - Develop FY02-06 F&E budget “wedge” for Safe Flight 21 limited deployment
- Costs reflect currently envisioned operational concepts and architecture
- Limited Deployment scope:
  - Ohio River Valley
    - Single/dual data links (6 scenarios)
  - State of Alaska
- FAA Life Cycle funding
  - Facilities and Equipment (F&E)
  - Operations and Maintenance (O&M)
- Industry equipage and maintenance costs
- Industry and FAA sunk costs prior to FY02 are not included

WBS Overview

<u>F&E Phase</u>

System Equipment
- Hardware/Software
- System Engineering
- Program Management
- System Test and Evaluation
- Data

System Installation
- Installation Design/Survey/Prep
- Installation and Checkout

Additional System Costs
- Telecom/Utilities/Leases
- Initial Maintenance
- Initial Spares
- Training
- Support Facility
- Program Office Support
- Support Equipment
- Engineering Change Orders (ECOs)

<u>O&M Phase</u>

Annual Maintenance
- Telecommunications/Utilities/Leases
- Repairables/Consumables
- Labor
  - Site Technician
  - Inventory Management
  - Repair
- Training
- Certification

Technical Baseline

- Case 1: Limited Deployment
  - Ohio River Valley
  - Alaska

Technical Baseline
Case 1: Limited Deployment Ohio River Valley

- Cost Estimate Scope
- Operational Concept
- System Buy Quantities
- General Ground Rules and Assumptions
- FAA System and WBS Descriptions
- Industry Aircraft Avionics Equipage Description
- Ohio River Valley Cost Results

Technical Baseline-ORV
Cost Estimate Scope

Estimate costs for:

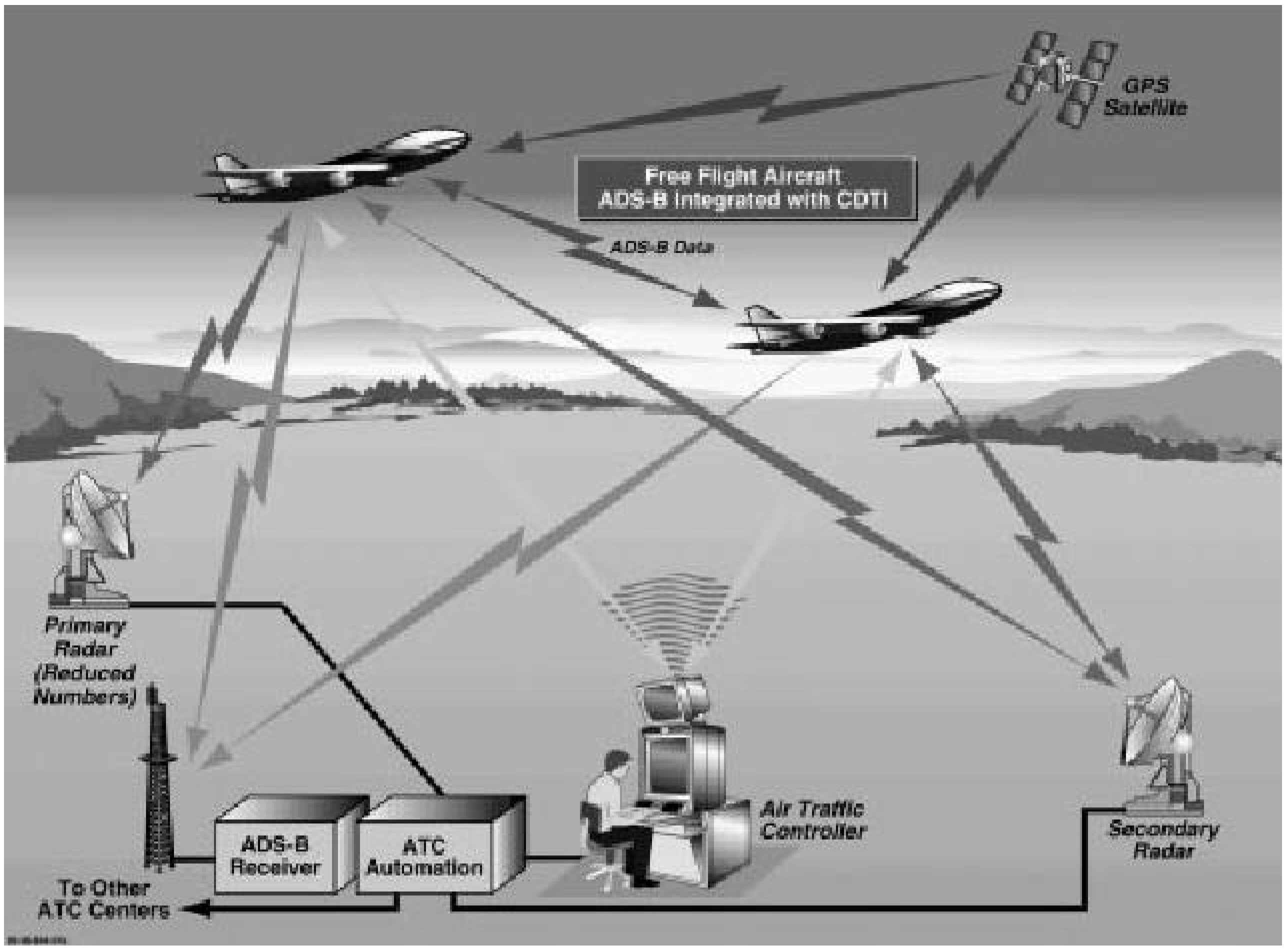
- Location
  - Memphis
  - Louisville
  - Wilmington
- FAA
  - ADS-B Ground Stations - En Route and Terminal
  - Vehicle ADS-B equipage (AIP funded?)
  - Avionics Development
  - Automation Interface
  - FIS-B Development/Automated Weather
  - Software Changes
  - TIS-B Development
  - NASA AMES, Program Office Support, and Regional/Tech Center Support

Technical Baseline-ORV
Cost Estimate Scope (Cont'd)

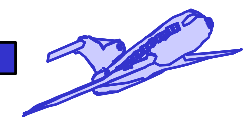
Estimate costs for:

- Industry
  - Aircraft Avionics Equipage
    - Airborne
    - UPS
    - FedEx

Technical Baseline-ORV
Operational Concept



Technical Baseline-ORV
System Buy Quantities



	Prior Years	FY02	FY03	FY04	FY05	**Total**
FAA						
Surface Requirements						
ADS-B Ground Stations - Enroute		2	3			5
ADS-B/Multilateration System - Terminal*	2	1				3
Vehicle ADS-B Equipage		75	75	75		225
Automation						
Multiprocessor - Enroute**		2				2
Multiprocessor - Terminal	2	1				3
Tower Display (2 per Multilateration System)	4	2				6
INDUSTRY						
Aircraft Avionics Equipage						
UPS	220	28				248
Airborne	4	60	53			117
Fedex	4	75	75	75	78	307

*Each system includes 8 ADS-B ground stations

**Includes format conversion hardware and PAMRI adapter cards

Technical Baseline-ORV
General Ground Rules and Assumptions

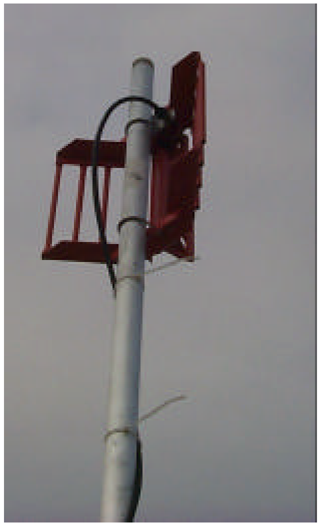
Programmatic

- All applications are technically feasible
- Hardware baseline will consist of STC approved TSO equipment
- Disposition costs are not included
- The analysis timeframe is FY02 through FY11 for Limited Deployment
- 1st 2 years of system telecommunications and utilities costs funded with F&E dollars
- Internet protocol not considered for telecommunications
- System contractor maintenance is funded with F&E dollars through FY05. Maintenance responsibility will transition to O&M in FY06

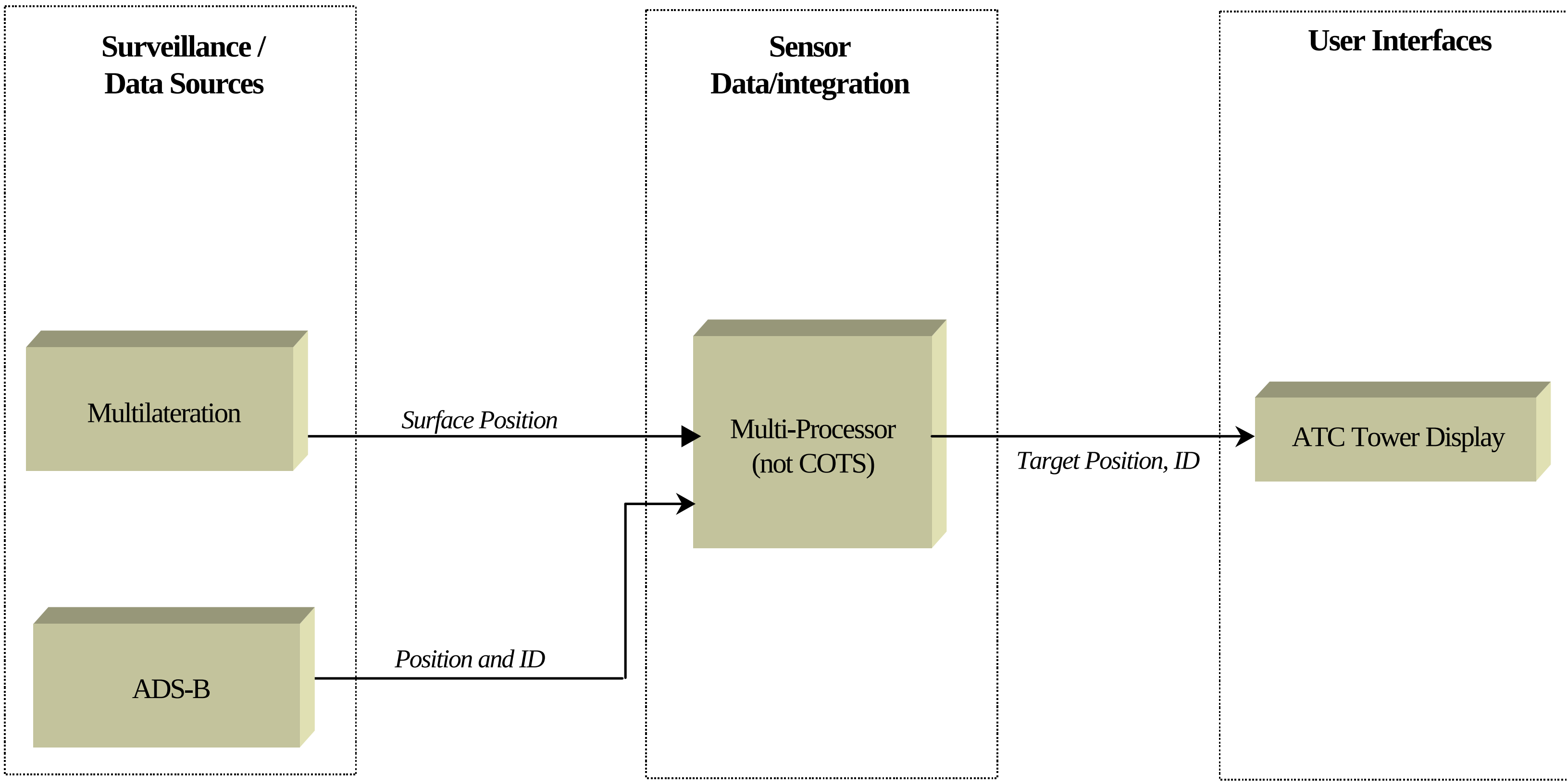
Estimating

- Costs are presented in FY00 constant and current year dollars
- Current year costs are derived by applying the OMB inflation indices provided in ACE-IT to the constant year costs

Technical Baseline-ORV
System Description - ADS-B Ground Station



Technical Baseline-ORV
ADS-B/Multilateration System Architecture - Terminal



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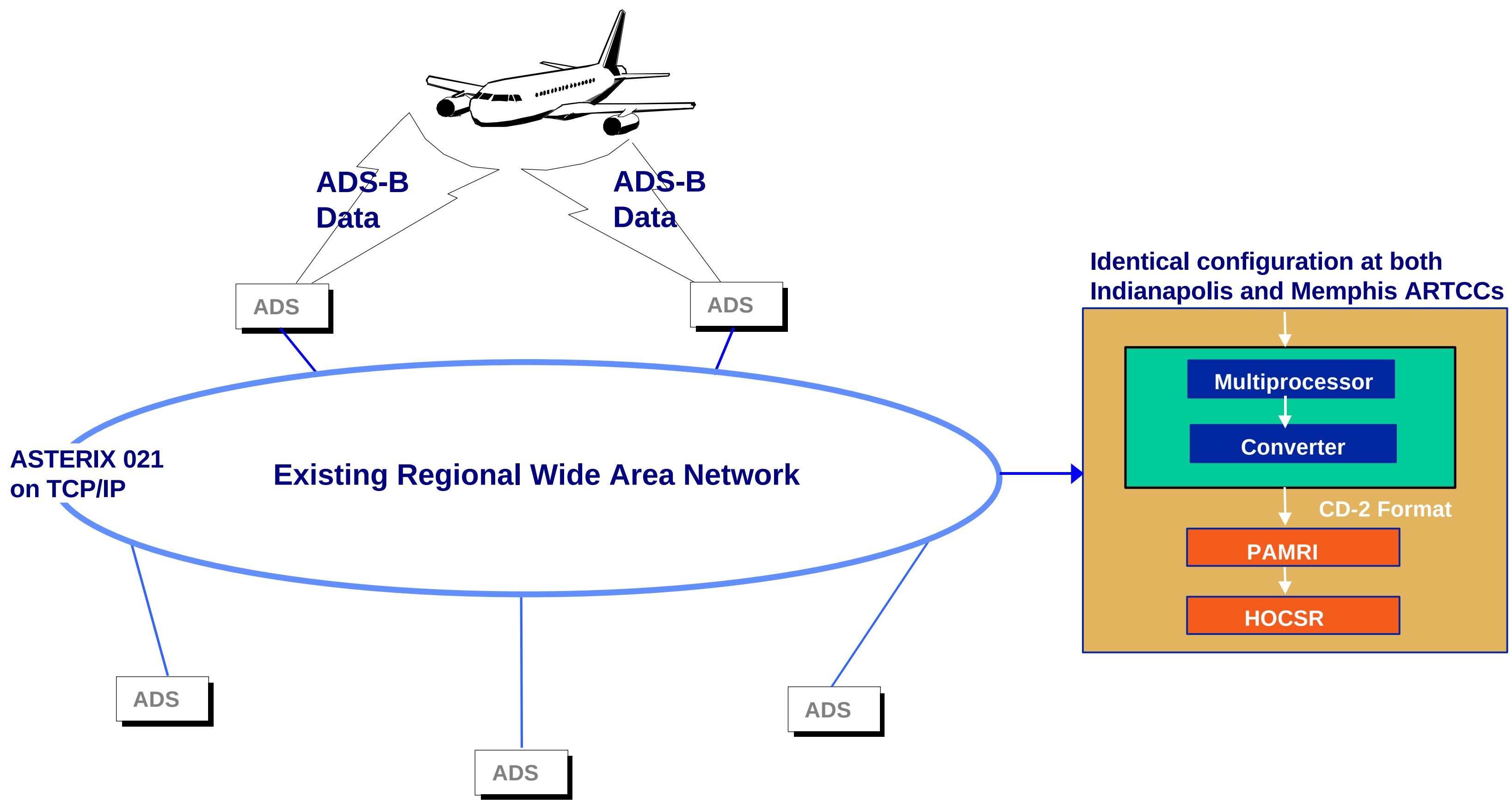
Preliminary Results

Technical Baseline-ORV
Initial En Route System Architecture



Technical Baseline-ORV
F&E WBS Descriptions - ADS-B Ground Station

System Equipment

- Description
  - ADS-B/Multilateration System - Terminal
    - 8 Ground Stations (Remote Units)
      - 4 R/T , 4 RO
    - 1 Redundant Central Processing Station
    - 1 Redundant Reference Transponder
    - 16 Telephone Line Modems
    - All associated antennas, cables and antenna structures
  - ADS-B Ground Stations - En Route
    - 1 Remote Unit (Receiver/Transmit Unit)
    - 2 lease line modems per ground station

Technical Baseline-ORV
F&E WBS Descriptions - ADS-B Ground Station (Cont'd)

System Equipment

- Ground Rules and Assumptions
  - 3 ADS-B/Multilateration systems required
    - 2 systems will be procured prior to FY02
    - The remaining system will be procured in FY02
    - Sensis vendor quote: system cost of $909K for single link configuration (1090) and $1,149K for dual link configuration
      - Includes PME, SE/PM, STE, and Data
    - Includes Non-Recurring First Article costs ($2.1M)

Technical Baseline-ORV
F&E WBS Descriptions - ADS-B Ground Station (Cont'd)

System Equipment

- Ground Rules and Assumptions (Cont'd)
  - 5 stand alone ADS-B ground stations required
    - All have R/T capabilities
    - 2 procured in FY02
    - 3 procured in FY03
    - Sensis vendor quote for 5 ground stations: $927K for single link configuration and $1077K for dual link configuration
      - Includes PME, SE/PM, STE, and Data
    - Annual non-recurring hardware cost of $240K in FY02

Technical Baseline-ORV
F&E WBS Descriptions - ADS-B Ground Station (Cont'd)

System Installation

- Description
  - ➢ Installation of equipment
  - ➢ System checkout and acceptance
    - ∗ Installation Survey/Design/Prep
    - ∗ System activation and integration with external interfaces
    - ∗ System optimization and OT&E dry run
- Ground Rules and Assumptions
  - ➢ Prime Contractor installation with government oversight
  - ➢ Sensis vendor quote
    - ∗ $239K per ADS-B/Multilateration system
    - ∗ $228K for 5 ADS-B ground stations
  - ➢ ADS-B ground stations will be located on existing structures; power, telecommunications, and security infrastructure in place

Technical Baseline-ORV
F&E WBS Descriptions - ADS-B Ground Station (Cont'd)

Additional System Costs

- Description
  - Leased Telecommunications/Utilities/Land Leases
  - Contractor Maintenance
  - Initial Site Spares
  - Training
  - Engineering Change Orders (ECOs)

- Ground Rules and Assumptions
  - Leased Telecommunications/Utilities/Land Leases
  - Contractor ICDLS and 2nd Level Maintenance
    - Sensis vendor quote
      - $133K per year per ADS-B/Multilateration system
      - $80K per year for 5 ADS-B ground stations

Technical Baseline-ORV
F&E WBS Descriptions - ADS-B Ground Station (Cont'd)

<u>Additional System Costs</u>

- Ground Rules and Assumptions (Cont'd)
  - Initial Site Spares
    - Sensis vendor quote
      - $106K per ADS-B/Multilateration system
      - $45K for ADS-B ground stations
  - Training
    - Conducted at Prime Contractor's facility
    - Sensis vendor quote of $12K per week
    - 5 courses for ATC training (1 week, 6 people per course)
    - 5 courses for Site maintenance training (2 weeks, 6 people per course)
    - Student time and travel costs for FAA personnel are included
  - Engineering Change Orders
    - 10% of system equipment and installation costs

Technical Baseline-ORV
O&M WBS Descriptions - ADS-B Ground Station

Annual Maintenance

- Description
  - Leased Telecommunications/Utilities/Land Leases
  - Maintenance
  - Training

- Ground Rules and Assumptions
  - Annual Telecommunications/Utilities/Leases
  - Annual maintenance cost of $133K per ADS-B/Multilateration system and $80K for 5 ADS-B ground stations
    - Includes O&M effort for multiprocessors and displays

Technical Baseline-ORV
O&M WBS Descriptions - ADS-B Ground Station (Cont'd)

Annual Maintenance

- Ground Rules and Assumptions (Cont'd)
  - Training
    - Sensis vendor quote of $12K per week
    - 2 courses for ATC training every four years (1 week, 6 people per course)
    - Student time and travel costs for FAA personnel are included

Technical Baseline-ORV
F&E WBS Descriptions-Vehicle ADS-B

<u>System Equipment/Installation/Additional Costs</u>

- Description
  - Low wattage ADS-B transmitter (UAT) with built-in GPS receiver and antenna
  - Installation
  - Maintenance
  - Spares
  - Engineering Change Orders (ECOs)
- Ground Rules and Assumptions
  - Vehicle ADS-B signal received by ground stations and sent to multiprocessor
  - 225 total units required
    - 75 procured in each year from FY02-FY04
    - Installed on Airport Authority, Crash, Fire, and Rescue, Security, and FAA vehicles
    - Unit Cost: $2K (includes installation)
    - Power supplied by vehicle battery

Technical Baseline-ORV
F&E WBS Descriptions-Vehicle ADS-B (Cont'd)

System Equipment/Installation/Additional Costs

- Ground Rules and Assumptions (Cont'd)
  - No annual maintenance
  - Equipment is consumable
  - 10% on-site spares (anticipated lifetime buy)
  - Engineering Change Orders
    - 10% of system equipment costs

Technical Baseline-ORV
F&E WBS Descriptions-Avionics Development

- Description
  - System integration of cockpit avionics to include:
    - Human factor analysis
    - Standard development of MASPS and MOPS
    - OpEval tests
- Ground Rules and Assumptions
  - Planning “wedge” provided by the Program Manager
  - Non-recurring cost of $959K in FY02

Technical Baseline-ORV
F&E WBS Descriptions - Automation: Multiprocessor - Terminal

<u>System Equipment/Installation</u>

- Description
  - Interfacing with multiple sensors
  - Fusing sensors to provide one output
  - Remote Maintenance Monitoring System (RMMS)
  - Data Logging

- Ground Rules and Assumptions
  - Multiprocessor required for each ADS-B/Multilateration System (3)
    - Unit cost of $363K
      - Includes an additional cost of $194K to incorporate the Terminal Automation Interface capability
      - 2 procured prior to FY02 are a sunk cost
      - 1 procured in FY02

F&E WBS Descriptions - Automation: Multiprocessor - En Route

System Equipment/Installation/Additional Costs

- Description
  - 2 ARTCCs (Indianapolis and Memphis), each includes:
    - Multiprocessor
    - Format conversion hardware
    - PAMRI adapter cards

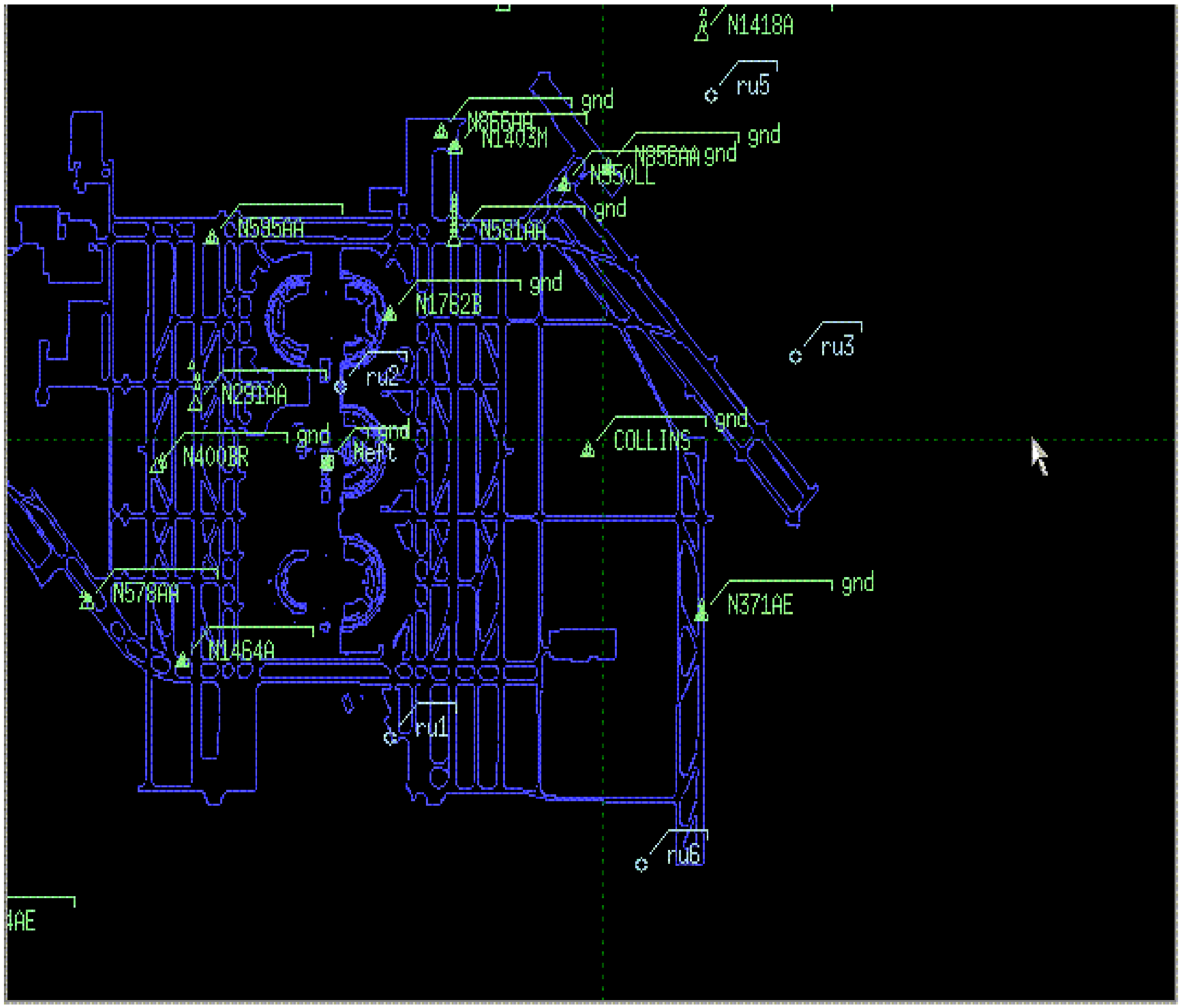
- Ground Rules and Assumptions
  - 2 multiprocessors procured in FY02, one for each ARTCC
  - Unit cost of $202K
    - $169K for the multiprocessor
    - $13K for the format conversion hardware
    - $20K per ARTCC for the PAMRI cards

Technical Baseline-ORV
F&E WBS Descriptions - Automation: Multiprocessor - En Route

<u>System Equipment/Installation/Additional Costs</u>

- Ground Rules and Assumptions (Cont'd)
  - Installation and Initial Support
    - 1 month per ARTCC
    - Total cost of $32K

Technical Baseline-ORV
System Description - Automation: Tower Display



Preliminary Results

Technical Baseline-ORV
F&E WBS Descriptions - Automation: Tower Display

System Equipment/Installation

- Description
  - 17 inch color displays
  - Readable in ATCT ambient light
  - HMI Display/Keyboard/Mouse
  - Capable of auto/manual display of Flight ID

- Ground Rules and Assumptions
  - 6 tower displays required (2 per ADS-B/Multilateration system)
    - Unit cost of $35K
      - 4 procured prior to FY02 are a sunk cost
      - 2 procured in FY02

Technical Baseline-ORV
F&E WBS Descriptions - FIS-B Development/Automated Weather

- Description
  - Development and implementation of FIS-B as an enabling technology
  - Will require modifications to the following:
    - Ground infrastructure
    - Avionics
    - Automation

- Ground Rules and Assumptions
  - Includes all non-recurring/recurring effort for FIS-B related upgrades/changes
  - Cost of $1,919K in FY02
  - Planning “wedge” provided by the Program Manager

Technical Baseline-ORV
F&E WBS Descriptions - Software Changes

- Description
  - Changes to terminal and surface automation software
    - Interface development
    - Fusion
    - ASTERIX
    - Conflict alerting

- Ground Rules and Assumptions
  - Total cost of $4,193K is spread across FY04 and FY05
  - Planning “wedge” provided by the Program Manager

Technical Baseline-ORV
F&E WBS Descriptions - TIS-B Development

- Description
  - Development and implementation of TIS-B as an enabling technology
  - Will require modifications to the following:
    - Ground infrastructure
    - Avionics
    - Automation

- Ground Rules and Assumptions
  - Includes all non-recurring/recurring effort for TIS-B related upgrades/changes
  - Total costs of $4,170 are spread across 3 years (FY03-FY05)
  - Planning “wedge” provided by the Program Manager

Technical Baseline-ORV
F&E WBS Descriptions - NASA AMES

- Description
  - Ongoing simulation activities to monitor/test performance of new technologies
- Ground Rules and Assumptions
  - Total cost of $2,589K - ROM costs provided by NASA AMES
    - FY02 - $767K
    - FY03 - $470K
    - FY04 - $460K
    - FY05 - $451K
    - FY06 - $441K

Technical Baseline-ORV
F&E WBS Descriptions - Program Office Support

- Description
  - TAC Support
  - Lincoln Lab/MIT
  - TRIOS
  - Sub-Systems
- Ground Rules and Assumptions
  - Program Office Support costs include:

		# FTEs				
Item	**Annual Salary ($K)**	**FY2002**	**FY2003**	**FY2004**	**FY2005**	**FY2006**
TAC Support	$175	8	8	7	7	3.5
Lincoln Lab/MIT	$300	3	3	3	3	1.5
TRIOS	$200	3	3	3	3	1.5
Subsystems	$300	3.5	3.5	3.5	3.5	2

Technical Baseline-ORV
F&E WBS Descriptions - Regional/Tech Center Support

- Description
  - RE/TOR
  - ACT

- Ground Rules and Assumptions
  - Regional/Tech Center Support costs include:

		# FTEs				
Item	**Annual Salary ($K)**	**FY2002**	**FY2003**	**FY2004**	**FY2005**	**FY2006**
RE/TOR	$183	3	3	3	3	1.5
ACT	$183	4	4	4	4	2

Technical Baseline-ORV
Cost Strategy for Aircraft Avionics

- Three categories of aircraft ADS-B equipage
  - Non-TCAS (add a new suite)
  - Existing TCAS (add a new LRU)
  - Hybrid TCAS/ADS-B (modify existing LRUs)
- Equipage costs identified for each category
  - Vendor quotes are rough order of magnitude and do not reflect economies of scale
  - Equipage costs are based on “average” fleet configuration and are not tail number specific
  - Incremental costs for dual link scenario
  - Costs do not differ by type of aircraft (747, 767, 757…)
  - Installation occurs during scheduled aircraft down time (C check, depot, etc..)
- Airborne and UPS aircraft have a Non-TCAS configuration
- FedEx aircraft will use a Hybrid TCAS/ADS-B configuration

Technical Baseline-ORV
System Description - Aircraft Avionics CDTI

Technical Baseline-ORV
System Description - Aircraft Avionics LDPU

Technical Baseline-ORV
Aircraft Avionics Equipage: Non-TCAS Configuration

System Equipment/Installation/Maintenance

- Description
  - Non-recurring activities (Simulator mods, Tech Pubs, Engineering, STC testing)
  - Equipment
    - LDPU
    - CDTI
    - Mode S Transponder
    - Radio (as needed)
  - Installation kit and labor
  - Spares
  - Annual Maintenance

Technical Baseline-ORV
Aircraft Avionics Equipage: Non-TCAS Configuration

System Equipment/Installation/Maintenance

- Ground Rules and Assumptions
  - Equipment procured/installed according to fleet retrofit schedule
  - Fleet size does not reflect potential buys in FY02-05
  - Non-recurring costs estimated at $900K per carrier
    - Sunk costs for UPS
  - Spares are assumed to be 10% of aircraft equipment cost
  - Annual maintenance is assumed to be $1K per LRU per aircraft
  - Hardware and Software integration included in ROM equipment costs
  - UAT T/R capability incorporated into LDPU, radio required for VDL4

Technical Baseline-ORV
Aircraft Avionics Non-TCAS Unit ROM Costs

Constant Year ($K/Aircraft)

	Single-Link			Dual-Link		
	1090	UAT	VDL4	1090/UAT	1090/VDL4	VDL4/UAT
Prime Mission Equipment						
LDPU	$60	$70	$50	$80	$60	$70
CDTI/Keypad	$50	$50	$50	$50	$50	$50
Mode-S Xponder	$30			$30	$30	
VDL4 Radio			$30		$30	$30
Installation						
Wire kit	$40	$35	$40	$45	$45	$45
Installation labor	$25	$25	$30	$30	$35	$35
Total	$205	$180	$200	$235	$250	$230

Technical Baseline-ORV
Aircraft Avionics Equipage: Hybrid TCAS/ADS-B

System Equipment/Installation/Maintenance

- Description
  - Non-recurring activities (Simulator mods, Tech Pubs, Engineering, STC testing)
  - Equipment
    - CDTI
    - Radio (as needed)
    - GPS
  - Installation kit and labor
  - Spares
  - Annual Maintenance

- Transponder upgrade
- TCAS computer upgrade (Chg. 7)
- TCAS computer software upgrade to ADS-B

Technical Baseline-ORV
Aircraft Avionics Equipage: Hybrid TCAS/ADS-B

System Equipment/Installation/Maintenance

- Ground Rules and Assumptions
  - Equipment procured/installed according to fleet retrofit schedule
  - Fleet size does not reflect potential buys in FY02-05
  - Non-recurring costs estimated at $900K per carrier
  - Spares are assumed to be 10% of aircraft equipment cost
  - Annual maintenance is assumed to be $1K per LRU per aircraft
  - Hardware and software integration included in ROM equipment costs
  - TCAS/ADS-B single link is assumed to be 1090
  - Assumes TCAS and Mode S installed on aircraft prior to ADS-B upgrade
    - Includes computer upgrade to TCAS Change 7
  - The cost for a hybrid CDTI/keyboard is $0-500K depending upon symbol generator replacement; FedEx has assumed an average cost of $50K per aircraft
  - FedEx does not need a transponder upgrade

Technical Baseline-ORV
Aircraft Avionics Hybrid TCAS/ADS-B Unit ROM Costs

Constant Year ($K/Aircraft)

	Single-Link			Dual-Link		
	1090	UAT	VDL4	1090/UAT	1090/VDL4	VDL4/UAT
Prime Mission Equipment						
CDTI/Keypad	$50*	$50*	$50*	$50*	$50*	$50*
GPS	$50	$50	$50	$50	$50	$50
VDL4 Radio			$30		$30	$30
UAT Radio		$30		$30		$30
TCAS computer software upgrade to ADS-B	$30	$35	$35	$35	$35	$35
Installation						
Wire kit	$1	$15	$15	$15	$15	$15
Installation labor	$5	$10	$10	$10	$10	$10
Total	$136	$190	$190	$190	$190	$220

*Range $0-500 depending on symbol generator replacement (high risk item)

Technical Baseline
Case 1: Limited Deployment Alaska

- Cost Estimate Scope
- Operational Concept
- System Buy Quantities
- General Ground Rules and Assumptions
- FAA System and WBS Descriptions
- Commercial Aircraft Avionics Description
- Alaska Cost Results

Technical Baseline-AK
Cost Estimate Scope

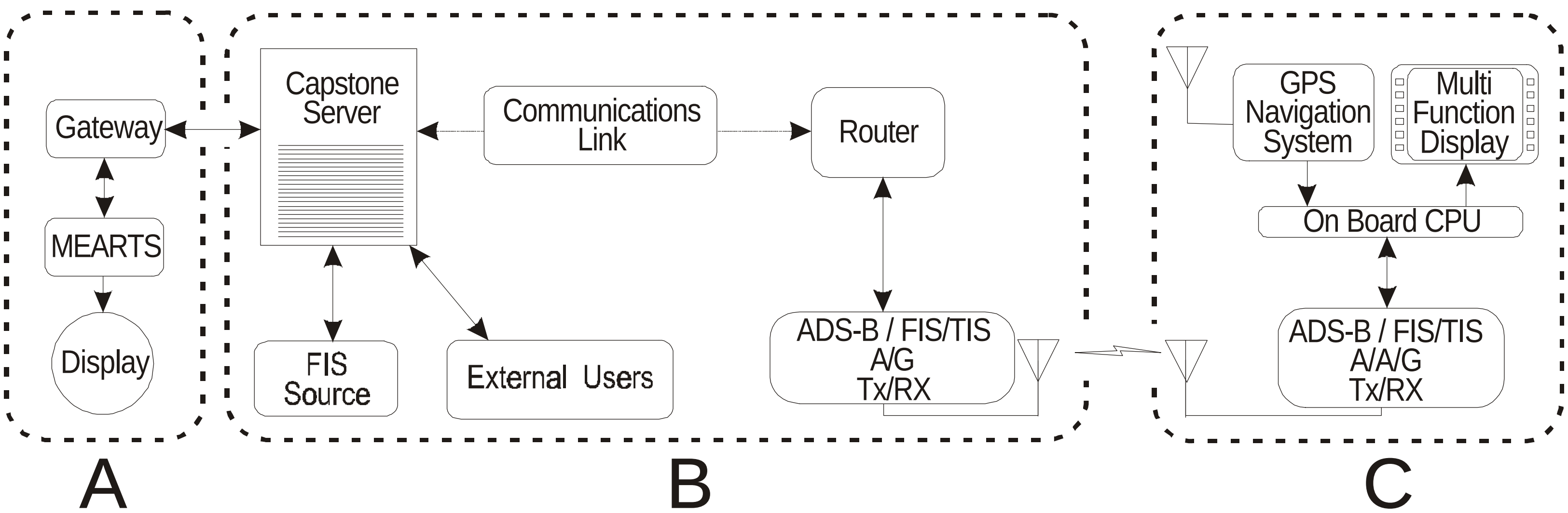
Estimate costs for:

- Introduction of new capabilities for aircraft, airports, flight service stations, and additional FAA locations to improve aviation safety and efficiency

- FAA
  - ADS-B Ground Broadcast Transceivers
  - Multiprocessors
  - LAAS
  - AWOS
  - Vehicle ADS-B
  - Automation
  - Capstone Program Office Support

- GA/Commercial aircraft avionics equipage
  - General Aviation
  - Air Taxi

Technical Baseline-AK
Operational Concept



A-NAS Automation Equipment

B-Ground Equipment

C-Avionics

Technical Baseline-AK
System Buy Quantities

	Prior Years	FY02	FY03	FY04	FY05	FY06	FY07	**Total**
FAA Requirements								
SURFACE REQUIREMENTS								
Ground Broadcast Transceiver	13*	50	50	50	38			**201**
Multiprocessor	1	3	3	3	3			**13**
LAAS	1	3	3	3	3			**13**
AWOS	14	12	8	8	7			**49**
Vehicle ADS-B	150	470	270	150	114			**1154**
CAPSTONE AIRCRAFT EQUIPAGE**	150							**150**
Industry Requirements								
GA/COMMERCIAL AIRCRAFT EQUIPAGE		750	750	750	750	750	100	**3850**

* R&D Systems
** GA/Commercial Aircraft Equipped by FAA for OpEvals

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Preliminary Results

Technical Baseline-AK
General Ground Rules and Assumptions

Programmatic

- All applications are technically feasible
- Hardware baseline will consist of STC approved TSO equipment
- Disposition costs are not included
- The analysis timeframe is FY02-FY11
- ADS-B data will be transmitted via the UAT datalink
- 1st 2 years of system telecommunications and utility costs funded with F&E dollars starting in year of system installation
- Annual maintenance labor costs funded with O&M dollars starting the year following installation
- Training costs include student time and travel costs for FAA personnel
- No systems require land leases

Estimating

- Costs are presented in FY00 constant and current year dollars
- Current year costs are derived by applying the OMB inflation indices provided in ACE-IT to the constant year costs

Technical Baseline-AK
F&E WBS Descriptions-Ground Broadcast Transceiver (GBT)

System Equipment

- Description
  - 19" Rack-mounted system
    - 2 Radios w/ built-in processors
    - UPS power supply
    - Remote maintenance monitoring equipment

- 2 GPS antennas
- 2 Datalink antennas

- Ground Rules and Assumptions
  - 201 systems required
    - One system per each Capstone location that has an air-to-ground radio (RCO-Remote Communication Outlet and/or RCAG-Remote Communication Air to Ground)
    - Locations optimized for line of sight
    - 13 R&D systems procured prior to FY02 are sunk costs
    - 188 systems procured from FY02-FY05

Technical Baseline-AK
F&E WBS Descriptions-GBT (Cont'd)

<u>System Equipment</u>

- Ground Rules and Assumptions (Cont'd)
  - UPS-AT quote for nonredundant, noncertified system: $40K
    - Doubled for redundancy and to account for uncertainty
    - Unit cost for certified system: $80K
    - Economies of scale not accounted for in quote
  - Single composite datalink system using UAT at frequency of 981 MHz

Technical Baseline-AK
F&E WBS Descriptions-GBT (Cont'd)

<u>System Installation</u>

- Description
  - Installation of equipment in existing FAA facilities
  - System checkout and acceptance
  - Modification to existing facilities as needed

- Ground Rules and Assumptions
  - No additional shelter costs needed
  - Antenna located on existing towers
  - Locations have power and telecommunications infrastructure in place
  - Installation performed by ANI in same year of system buy
  - Installation and site acceptance: $20.8K per site
    - Based on 2 man-months of effort
    - GS-14, Step 5 Annual Labor Rate: $122K
    - Travel: 1 trip per site, $500 per trip

Technical Baseline-AK
F&E WBS Descriptions-GBT (Cont'd)

<u>Additional System Costs</u>

- Description
  - Leased Telecommunications/Utilities
  - Spares
  - Training
  - Program Office Support
  - Engineering Change Orders (ECOs)

- Ground Rules and Assumptions
  - Annual telecommunications costs to lease satellite bandwidth for transferring ADS-B aircraft data to Anchorage
    - 52 sites use FAA ANICS system: $10.8K per site
    - Assumes ANICS bandwidth will be available
    - 136 sites use commercial vendor: $36K per site

Technical Baseline-AK
F&E WBS Descriptions-GBT (Cont'd)

<u>Additional System Costs</u>

- Ground Rules and Assumptions
  - Annual Power: $5.7K per site
  - Spares
    - No on-site spares required
    - 20% centralized depot spares pool located in Anchorage
  - Training
    - H/W and S/W Maintenance:
      - Cadre training: Two 2-week courses, 5 students each
      - Cost per course: $53.9K
    - ATC (Multipurpose System Familiarization) Training:
      - Cadre Training: Three 1-week courses, 10 students each,
      - Cost per course: $44.4K

Technical Baseline-AK
F&E WBS Descriptions-GBT (Cont'd)

<u>Additional System Costs</u>

- Ground Rules and Assumptions
  - Annual Program Office support
    - 2 support contractors to support acquisition and implementation activities
    - Annual labor rate: $133K
  - No support equipment required
  - Engineering Change Orders (ECOs)
    - 10% of system equipment and installation costs

Technical Baseline-AK
O&M WBS Descriptions-GBT

Annual Maintenance

- Description
  - Leased Telecommunications/Utilities
  - Repairables/Consumables
  - System Support Center Maintenance
  - Training
  - Certification

- Ground Rules and Assumptions
  - Annual telecommunications costs to lease satellite bandwidth for transferring ADS-B aircraft data to Anchorage
    - 52 sites use FAA ANICS system: $10.8K per site
    - 136 sites use commercial vendor: $36K per site
  - Annual Power: $5.7K per site
  - Repairables/Consumables: $2K per system per year

Technical Baseline-AK
O&M WBS Descriptions-GBT (Cont'd)

<u>Annual Maintenance</u>

- Ground Rules and Assumptions
  - System Support Center Maintenance Labor
    - Based on 1 man-year per 20 transceivers
    - GS-12, Step 5 Annual Labor Rate: $86K
    - Travel: 1 trip per site, $500 per trip
  - Training
    - H/W and S/W Maintenance Refresher Training:
      - Cadre training: Two 1-week courses, 5 students each, every 4 years
      - Cost per course: $28.2K
    - ATC Attrition Training:
      - Cadre Training: One 1-week course, 10 students, every 4 years
      - Cost per course: $44.4K
  - No certification activities

Technical Baseline-AK
F&E WBS Descriptions-Multiprocessors

System Equipment

- Description
  - Fusion platform for surface(where available)/long range radar data with ADS-B data
  - Automation/interfaces
  - Displays

- Ground Rules and Assumptions
  - 13 multiprocessors required
    - Anchorage server procured prior to FY02 is a sunk cost
    - Located at 12 additional high traffic airports
  - VNTSC unit quote: $169K
  - Display costs not included

Technical Baseline-AK
F&E WBS Descriptions-Multiprocessors (Cont'd)

<u>System Installation</u>

- Description
  - Installation of equipment in existing FAA facilities
  - System checkout and acceptance
  - Modification to existing facilities as needed

- Ground Rules and Assumptions
  - Locations have power and telecommunications infrastructure in place
  - LAN infrastructure in place
  - Installation performed by ANI in year of system buy
  - Installation and site acceptance: $20.8K per site
    - Based on 2 man-months of effort
    - GS-14, Step 5 Annual Labor Rate: $122K
    - Travel: 1 trip per site, $500 per trip

Technical Baseline-AK
F&E WBS Descriptions-Multiprocessors (Cont'd)

Additional System Costs

- Description
  - Leased Telecommunications/Utilities
  - Spares
  - Training
  - Program Office Support
  - Engineering Change Orders (ECOs)

- Ground Rules and Assumptions
  - Annual telecommunications and utilities
  - 3 year warranty (parts and labor) included in equipment buy
  - Spares
    - No on-site spares required
    - 10% centralized depot spares pool located in Anchorage

Technical Baseline-AK
F&E WBS Descriptions-Multiprocessors (Cont'd)

<u>Additional System Costs</u>

- Ground Rules and Assumptions (Cont'd)
  - Training
    - H/W and S/W Maintenance:
      - Cadre training: Two 2-week courses, 5 students each
      - Cost per course: $53.9K
  - Annual Program Office support
    - 1 support contractor to support acquisition and implementation activities
    - Annual Labor rate: $133K
  - No support equipment required
  - Engineering Change Orders (ECOs)
    - 10% of system equipment and installation costs

Technical Baseline-AK
O&M WBS Descriptions-Multiprocessor

Annual Maintenance

- Description
  - Leased Telecommunications/Utilities
  - Repairables/Consumables
  - System Support Center Maintenance
  - Training
  - Certification

- Ground Rules and Assumptions
  - Annual telecommunications and utility costs
  - Repairables/Consumables
  - System Support Center Maintenance Labor
    - Based on 1 man-year per 10 multiprocessors
    - GS-12, Step 5 Annual Labor Rate: $86K
    - Travel: 1 trip per site, $500 per trip

Technical Baseline-AK
O&M WBS Descriptions-Multiprocessor (Cont'd)

Annual Maintenance

- Ground Rules and Assumptions
  - Training
    - H/W and S/W Maintenance Refresher Training:
      - Cadre training: Two 1-week courses, 5 students each, every 4 years
      - Cost per course: $28.2K
  - No certification activities

Technical Baseline-AK
F&E WBS Descriptions-LAAS

System Equipment

- Description
  - Ground station includes:
    - Processor
    - Multiple GPS receivers
    - VHF data transmitter
    - Pseudolites (where needed)
    - Remote Maintenance Monitoring

- Ground Rules and Assumptions
  - 13 CAT I systems required, co-located at airports with ILS
    - Anchorage system procured prior to FY02 is a sunk cost
    - Located at 12 additional high traffic airports
  - Unit Cost: $461K, from SAT/NAV IA Report
  - Capstone systems are not included in the LAAS APB
  - Upgrades to CAT II/III systems are not included
  - Avionics costs included under user equipage costs

Technical Baseline-AK
F&E WBS Descriptions-LAAS (Cont'd)

System Installation

- Description
  - Surveys to determine precise locations for ground stations
  - Installation of equipment on airport surface
  - System checkout and acceptance
  - Modification to existing facilities as needed

- Ground Rules and Assumptions
  - Installation performed by ANI in year of system buy
  - Installation and Site Acceptance: $20.8K per site
    - Based on 2 man-months of effort
    - GS-14, Step 5 Annual Labor Rate: $122K
    - Travel: 1 trip per site, $500 per trip

Technical Baseline-AK
F&E WBS Descriptions-LAAS (Cont'd)

Additional System Costs

- Description
  - Leased Telecommunications/Utilities
  - Spares
  - Training
  - Program Office Support
  - Engineering Change Orders (ECOs).
  - Flight Checks and Approach Procedure Development

- Ground Rules and Assumptions
  - Annual telecommunications costs for Remote Maintenance Monitoring: $2.1K (POTS) per site
  - Annual utilities, buildings, and ground maintenance: $13K per site
  - Spares
    - No on-site spares required
    - 20% centralized depot spares pool located in Anchorage

Technical Baseline-AK
F&E WBS Descriptions-LAAS (Cont'd)

Additional System Costs

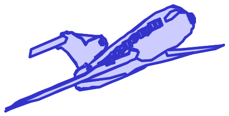
- Ground Rules and Assumptions (Cont'd)
  - Training
    - H/W and S/W Maintenance:
      - Cadre training: Two 2-week courses, 5 students each
      - Cost per course: $53.9K
  - Annual Program Office support
    - 2 support contractors to support acquisition and implementation activities
    - Annual labor rate: $133K
  - No support equipment required
  - Engineering Change Orders (ECOs)
    - 10% of system equipment and installation costs

Technical Baseline-AK
F&E WBS Descriptions-LAAS (Cont'd)

Additional System Costs

- Ground Rules and Assumptions (Cont'd)
  - Flight checks and approach procedure development
    - $12K for initial site in year of installation
    - $7.5 K for remaining sites in year of installation

Technical Baseline-AK
O&M WBS Descriptions-LAAS



Annual Maintenance

- Description
  - ➢ Leased Telecommunications/Utilities
  - ➢ Repairables/Consumables
  - ➢ System Support Center Maintenance
  - ➢ Training
  - ➢ Certification

- Ground Rules and Assumptions
  - ➢ Annual telecommunications and utility costs
    - * Telecommunications costs for Remote Maintenance Monitoring: $2.1K (POTS) per site
    - * Utilities, buildings, and ground maintenance: $13K per site
  - ➢ Repairables/Consumables
    - * $4.6K per system per year, from SAT/NAV IA Report

Technical Baseline-AK
O&M WBS Descriptions-LAAS (Cont'd)

<u>Annual Maintenance</u>

- Ground Rules and Assumptions
  - System Support Center Maintenance Labor
    - Based on 1 man-year per 10 systems
    - GS-12, Step 5 Annual Labor Rate: $86K
    - Travel: 1 trip per site, $500 per trip
  - Training
    - H/W and S/W Maintenance Refresher Training:
      - Cadre training: Two 1-week courses, 5 students each, every 4 years
      - Cost per course: $28.2K
  - No certification activities

Technical Baseline-AK
AWOS System

Technical Baseline-AK
F&E WBS Descriptions-AWOS

System Equipment

- Description
  - Qualimetrics AWOS III weather systems:
    - Airfield Sensor Group - (Winds, Temperature, Rain,…etc.)
    - Data Collection Platform - (Sensor interface, Modem/UHF Radio, Barometric Pressure Sensor Assembly, Power Supply)
    - Central Data Platform - (Modem/UHF Radio, VHF Radio, Card Cage, System Processor Panel)
    - Data Distribution Group - (Telephone, VHF Radio, Earphone/Speaker, Microphone, Operator and Handheld Terminals)
    - Remote Maintenance Monitoring
- Ground Rules and Assumptions
  - 49 AWOS III systems required
    - Located at remote airports where nonprecision GPS approach procedures are used
    - 14 systems procured prior to FY02 are sunk costs
    - 35 systems procured in FY02-FY05

Technical Baseline-AK
F&E WBS Descriptions-AWOS

System Equipment

- Ground Rules and Assumptions (Cont'd)
  - Unit Cost: $65K
  - Systems are not currently part of the AWOS APB
  - Costs to add video weather cameras not included

Technical Baseline-AK
F&E WBS Descriptions-AWOS (Cont'd)

<u>System Installation</u>

- Description
  - Installation of equipment at runway locations
  - System checkout and acceptance
  - Modification to existing facilities as needed

- Ground Rules and Assumptions
  - Installation performed by ANI approximately 1000 ft. off runway
  - Installation cost: $318K per site
    - Non-recurring telecommunications and utilities
      - Telecommunications: $50K based on factor applied to actuals
      - Power: $15K
    - Shelter costs: $12K
    - Gravel pad and road construction: $220K
      - Based on factor applied to Bethel actuals

Technical Baseline-AK
F&E WBS Descriptions-AWOS (Cont'd)

<u>System Installation</u>

- Ground Rules and Assumptions
  - Installation cost (Cont'd)
    - Labor: $20.8K
      - Based on 2 man-months of effort
      - GS-14, Step 5 Annual Labor Rate: $122K
      - Travel: 1 trip per site, $500 per trip

Technical Baseline-AK
F&E WBS Descriptions-AWOS (Cont’d)

Additional System Costs

- Description
  - Leased Telecommunications/Utilities
  - Spares
  - Training
  - Program Office Support
  - Engineering Change Orders (ECOs)

- Ground Rules and Assumptions
  - Annual Telecommunications and Utilities:
    - Telecommunications: $38.1K per site
      - Weather Data: $36K (Commercial vendor)
      - Remote Maintenance Monitoring: $2.1K (POTS)
    - Power: $7.3K per site

Technical Baseline-AK
F&E WBS Descriptions-AWOS (Cont'd)

Additional System Costs

- Ground Rules and Assumptions
  - No land leases required
  - Spares
    - No on-site spares required
    - 10% centralized depot spares pool located in Anchorage
  - Training
    - H/W and S/W Maintenance:
      - Delta training for AWOS trained technicians: Two 1-week courses, 5 students each
      - Cost per course: $28.2K

Technical Baseline-AK
F&E WBS Descriptions-AWOS (Cont'd)

Additional System Costs

- Ground Rules and Assumptions (Cont'd)
  - Annual Program Office support
    - 3 support contractor or FAA personnel to support acquisition and implementation activities
    - Annual labor rate: $133K
  - Support Equipment: $1.8K
    - 3 calibration paddles, one for every ten sites
    - Unit Cost: $600
  - Engineering Change Orders (ECOs)
    - 10% of system equipment and installation costs

Technical Baseline-AK
O&M WBS Descriptions-AWOS

Annual Maintenance

- Description
  - Leased Telecommunications/Utilities
  - Repairables/Consumables
  - System Support Center Maintenance
  - Training
  - Certification

- Ground Rules and Assumptions
  - Annual Telecommunications and Utilities:
    - Telecommunications: $38.1K per site
      - Weather Data: $36K (Commercial vendor)
      - Remote Maintenance Monitoring: $2.1K (POTS)
    - Power: $7.3K per site
  - Repairables/Consumables

Technical Baseline-AK
O&M WBS Descriptions-AWOS (Cont'd)

Annual Maintenance

- Ground Rules and Assumptions
  - System Support Center Maintenance Labor
    - Based on 1 man-year per 10 AWOS systems
    - GS-12, Step 5 Annual Labor Rate: $86K
    - Travel: 1 trip per site, $500 per trip
  - Training
    - H/W and S/W Maintenance Refresher Training:
      - Delta training for AWOS trained technicians: One 1-week courses, 5 students each, every 4 years
      - Cost per course: $28.2K
- No certification activities

Technical Baseline-AK
F&E WBS Descriptions-Vehicle ADS-B

System Equipment

- Description
  - Low wattage ADS-B transmitter (UAT) with built-in GPS receiver and antenna
  - Transmitter antenna
- Ground Rules and Assumptions
  - 1154 total units required for 200 airports
    - Installed on Government-owned snow plows, tractors, or other critical airport equipment that may occupy the runway
    - 150 units procured for Anchorage prior to FY02 are sunk costs
    - 200 units at large airports in FY02
      - Fairbanks: 100
      - Juneau: 50
      - Bethel: 50
    - 240 units in 8 other large airports: 30 each
    - 564 units in 188 smaller Capstone airports: 3 each

Technical Baseline-AK
F&E WBS Descriptions-Vehicle ADS-B (Cont'd)

System Equipment

- Ground Rules and Assumptions (Cont'd)
  - Unit Cost: $2K (includes installation)
  - Power supplied by vehicle battery
  - No processor/display system required

Technical Baseline-AK
F&E WBS Descriptions-Vehicle ADS-B (Cont'd)

System Installation

- Description
  - Equipment installed in airport vehicles
  - System checkout and acceptance

- Ground Rules and Assumptions
  - Installation costs included in system equipment costs

Technical Baseline-AK
F&E WBS Descriptions-Vehicle ADS-B (Cont'd)

Additional System Costs

- Description
  - Spares
  - Program Office Support
  - Engineering Change Orders (ECOs)
- Ground Rules and Assumptions
  - No annual maintenance
  - Equipment is consumable
  - 10% on-site spares (anticipated lifetime buy)
  - Annual Program Office support
    - 1/2 support contractor FTE to support acquisition and implementation activities
    - Annual labor rate: $133K
  - No support equipment required
  - Engineering Change Orders (ECOs)
    - 10% of system equipment and installation costs

Technical Baseline-AK
F&E WBS Descriptions-Automation

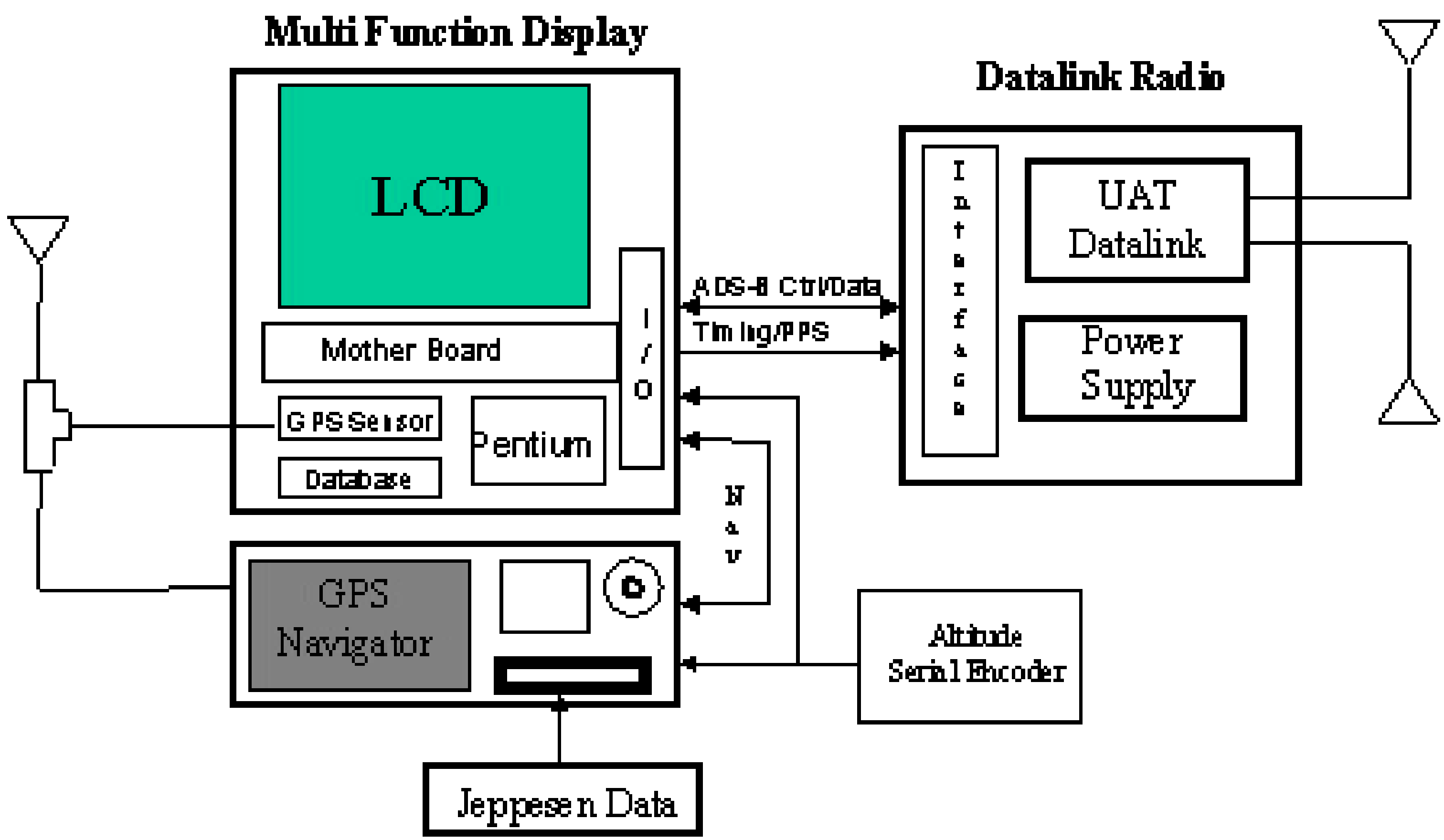
- Description
  - Modify, test, and certify the ground broadcast receiver software and the Capstone server software
  - Additional Micro-EARTS software updates

- Ground Rules and Assumptions
  - Modification cost to M-EARTS to accept ADS-B targets a sunk cost: $2.8M
  - Cost per year: $500K

Technical Baseline-AK
F&E WBS Descriptions-Capstone Program Office

- Description
  - Contractor support (NISC)
  - FIS subscriptions
    - 2 commercial vendors supply FAA with consolidated data in format capable of transmitting over a datalink
    - NOTEMS, PIREPS, basic weather information, and SUA
    - Miscellaneous (rental, supplies, exhibitions, studies, etc.)
  - FTEs: FS/AT personnel (O&M)
    - Flight Standards/Operational Procedures and Specs
    - AT Operational Procedures
- Ground Rules and Assumptions
  - NISC costs include a cost per man-year of $133K
    - 3 FTEs in FY02-FY04 and FY06, 3.5 FTEs in FY05
  - Miscellaneous costs are $250K per year
  - Annual FIS subscription cost: $100K
  - FS/AT personnel costs include a cost per man-year of $88K and 4 FTEs per year (O&M)

Technical Baseline-AK
Aircraft Avionics



Technical Baseline-AK
Aircraft Avionics

Technical Baseline-AK
WBS Descriptions-Aircraft Avionics Equipage

System Equipment

- Description
  - 1 GX60 NAVCOM GPS Radio
  - MX-20 MFD Display
  - 2 UAT antennas (located on top and bottom of aircraft)
  - Digital encoded altimeter
  - Wiring harness

- Ground Rules and Assumptions
  - 4000 total aircraft equipped
    - Standard system configuration for all equipping aircraft (wiring harness compatible across a wide variety of aircraft)
    - Military aircraft not included
    - 150 Capstone aircraft equipped prior to FY02 are sunk costs
    - 3850 additional aircraft equipped from FY02-FY07

Technical Baseline-AK
WBS Descriptions-Aircraft Avionics Equipage (Cont'd)

System Equipment

- Ground Rules and Assumptions (Cont'd)
  - Does not include new acquisitions
  - Unit cost of $16.5K per suite
    - Includes $2K for LAAS/WAAS-compatibility
    - Does not reflect economies of scale
  - UAT antennas can serve multiple GPS receivers

Technical Baseline-AK
WBS Descriptions-Aircraft Avionics Equipage (Cont'd)

System Installation

- Description
  - Avionics installation, checkout, certification and acceptance in aircraft

- Ground Rules and Assumption
  - Cost of $3.6K per system
  - Wiring harness cost included in system equipment costs

Technical Baseline-AK
WBS Descriptions-Aircraft Avionics Equipage (Cont'd)

Additional System Costs

- Description
  - Annual Maintenance
  - Flashcard Upgrades
  - Support Equipment

- Ground Rules and Assumptions
  - Annual Maintenance
    - Service life of 10 years
    - 1 year warranty (90 days parts and maintenance included)
    - Average annual maintenance: $60, UPS-AT quote ($300 every 5 years)

Technical Baseline-AK
WBS Descriptions-Aircraft Avionics Equipage (Cont'd)

Additional System Costs

- Ground Rules and Assumptions (Cont'd)
  - Flash card upgrades
    - GPS navigation database (every 60 days)
    - Terrain database (once a year)
      - Includes obstacle database
    - Annual cost for each: $300
  - No periodic avionics upgrades included
  - No support equipment needed

Cost Results

- Ohio River Valley
  - FAA F&E Costs
  - FAA O&M Costs
  - Industry Aircraft Avionics Equipage Costs

- Alaska
  - FAA F&E Costs
  - FAA Detailed F&E Costs
  - FAA O&M Costs
  - GA/Commercial Avionics Equipage Costs

Cost Results-ORV
FAA F&E Costs FY02-FY06

Total Cost - Current Year $K	Quantity		Datalink	
	Prior Yrs	To Complete	Single-Link	Dual-Link
GROUND INFRASTRUCTURE			**$8,817**	**$9,266**
ADS-B Ground Stations - Enroute		**5**	**$2,300**	**$2,474**
System Equipment			$1,250	$1,408
System Installation			$241	$241
Additional System Costs			$810	$826
ADS-B/Multilateration System - Terminal	**2**	**1**	**$5,942**	**$6,217**
System Equipment			$3,125	$3,375
System Installation			$249	$249
Additional System Costs			$2,568	$2,593
Vehicle ADS-B Equipage		**225**	**$575**	**$575**
System Equipment			$479	$479
System Installation			$0	$0
Additional System Costs			$96	$96
AVIONICS DEVELOPMENT			**$1,000**	**$1,000**
AUTOMATION INTERFACE			**$906**	**$906**
Multiprocessor-Enroute		**2**	**$455**	**$455**
System Equipment			$421	$421
System Installation			$33	$33
Multiprocessor-Terminal	**2**	**1**	**$378**	**$378**
Displays	**4**	**2**	**$73**	**$73**
FIS-B DEVELOPMENT/AUTOMATED WEATHER			**$2,000**	**$2,000**
SOFTWARE CHANGES			**$4,600**	**$4,600**
TIS-B DEVELOPMENT			**$4,500**	**$4,500**
NASA/AMES			**$2,800**	**$2,800**
PROGRAM OFFICE SUPPORT			**$18,835**	**$18,835**
REGIONAL/TECH CENTER SUPPORT			**$6,238**	**$6,238**
TOTAL			**$49,696**	**$50,145**

Cost Results-ORV
FAA O&M Costs FY04-FY11

Total Costs - Current Year $K	Single and Dual Link
GROUND INFRASTRUCTURE	**$5,555**
ADS-B Ground Stations - Enroute	$2,290
ADS-B/Multilateration System - Terminal	$3,265
AUTOMATION INTERFACE	**
TOTAL	**$5,555**

**Maintenance costs included in ADS-B Ground Stations - Enroute

Cost Results-ORV

Industry Aircraft Avionics Equipage Costs - FY02-FY11 (Current Year $K)

	Quantity		Datalink Cases (To Complete)					
	Prior Yrs	To Complete	1090 Mode S	UAT	VDL4	1090/UAT	1090/VDL4	UAT/VDL4
AIRCRAFT AVIONICS EQUIPPAGE			**$95,374**	**$109,990**	**$117,083**	**$122,713**	**$129,065**	**$135,292**
UPS (Non-TCAS)	**220**	**28**	**$14,836**	**$11,233**	**$14,661**	**$15,770**	**$19,052**	**$15,595**
System Equipment			$4,086	$3,503	$3,794	$4,670	$4,962	$4,378
System Installation			$1,897	$1,751	$2,043	$2,189	$2,335	$2,335
Additional System Costs			$8,852	$5,979	$8,823	$8,911	$11,754	$8,882
Airborne (Non-TCAS)	**4**	**113**	**$30,492**	**$26,113**	**$29,778**	**$34,298**	**$37,369**	**$33,585**
System Equipment			$17,592	$15,213	$16,402	$19,971	$21,161	$18,782
System Installation			$7,732	$7,137	$8,327	$8,922	$9,516	$9,516
Additional System Costs			$5,168	$3,762	$5,049	$5,406	$6,692	$5,287
FEDEX (Hybrid TCAS/ADS-B)	**4**	**303**	**$50,046**	**$72,644**	**$72,644**	**$72,644**	**$72,644**	**$86,113**
System Equipment			$40,773	$52,185	$52,185	$52,185	$52,185	$61,966
System Installation			$652	$8,151	$8,151	$8,151	$8,151	$8,151
Additional System Costs			$8,621	$12,308	$12,308	$12,308	$12,308	$15,995

Cost Results-AK
FAA F&E Costs

Phased Quantities/Costs (Current Year $K)	UAT DATALINK						
Cost Element	Prior Years	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	Total
SURFACE REQUIREMENTS		**$19,795**	**$19,175**	**$19,723**	**$17,888**	**$2,206**	**$78,787**
Ground Broadcast Transceivers							**$0**
Quantity	13	50	50	50	38		**201**
Cost		$8,526	$10,178	$10,998	$9,538	$1,795	**$41,034**
Multiprocessor							$0
Quantity	1	3	3	3	3		**13**
Cost		$900	$919	$880	$899	$0	**$3,599**
LAAS							$0
Quantity	1	3	3	3	3		**13**
Cost		$2,366	$2,448	$2,441	$2,492	$52	**$9,798**
AWOS							$0
Quantity	14	12	8	8	7		**49**
Cost		$6,757	$4,869	$4,940	$4,519	$360	**$21,445**
Vehicle ADS-B (Cost)							$0
Quantity	150	470	270	150	114		**1,154**
Cost		$1,245	$760	$463	$441	$0	**$2,910**
AUTOMATION REQUIREMENTS		**$521**	**$532**	**$543**	**$555**	**$0**	**$2,151**
CAPSTONE PROGRAM OFFICE SUPPORT		**$781**	**$797**	**$814**	**$943**	**$848**	**$4,183**
TOTAL COSTS		**$21,097**	**$20,504**	**$21,080**	**$19,386**	**$3,055**	**$85,121**

Cost Results-AK
FAA F&E Detailed Costs

Phased Annual Costs-Current Year $K	UAT DATALINK					
Cost Element	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	Total
SURFACE REQUIREMENTS	**$19,795**	**$19,175**	**$19,723**	**$17,888**	**$2,206**	**$78,787**
Ground Broadcast Transceivers	**$8,526**	**$10,178**	**$10,998**	**$9,538**	**$1,795**	**$41,034**
System Equipment	$4,170	$4,257	$4,347	$3,373	$0	$16,147
System Installation	$1,082	$1,105	$1,128	$875	$0	$4,190
Additional System Costs	$3,274	$4,816	$5,523	$5,289	$1,795	$20,697
Multiprocessor	**$900**	**$919**	**$880**	**$899**	**$0**	**$3,599**
System Equipment	$529	$540	$551	$563	$0	$2,182
System Installation	$65	$66	$68	$69	$0	$268
Additional System Costs	$307	$313	$261	$267	$0	$1,149
LAAS	**$2,366**	**$2,448**	**$2,441**	**$2,492**	**$52**	**$9,798**
System Equipment	$1,442	$1,472	$1,503	$1,535	$0	$5,952
System Installation	$65	$66	$68	$69	$0	$268
Additional System Costs	$859	$910	$870	$888	$52	$3,579
AWOS	**$6,757**	**$4,869**	**$4,940**	**$4,519**	**$360**	**$21,445**
System Equipment	$813	$553	$565	$505	$0	$2,436
System Installation	$3,975	$2,706	$2,762	$2,468	$0	$11,911
Additional System Costs	$1,969	$1,610	$1,613	$1,546	$360	$7,098
Vehicle ADS-B	**$1,245**	**$760**	**$463**	**$441**	**$0**	**$2,910**
System Equipment	$980	$575	$326	$306	$0	$2,187
System Installation	$0	$0	$0	$0	$0	$0
Additional System Costs	$265	$186	$137	$135	$0	$724
AUTOMATION REQUIREMENTS	**$521**	**$532**	**$543**	**$555**	**$0**	**$2,151**
CAPSTONE PROGRAM OFFICE SUPPORT	**$781**	**$797**	**$814**	**$943**	**$848**	**$4,183**
Supplies/Miscellaneous	$261	$266	$272	$277	$283	$1,359
Contractor Support (NISC)	$416	$425	$434	$554	$452	$2,281
FIS Subscriptions	$104	$106	$109	$111	$113	$544
TOTAL COSTS	**$21,097**	**$20,504**	**$21,080**	**$19,386**	**$3,055**	**$85,121**

Cost Results-AK
FAA O&M Costs

Total Costs - Current Year $K	UAT DATALINK
Cost Element	**Total**
SURFACE REQUIREMENTS	**$86,401**
Ground Broadcast Transceivers	$58,014
Multiprocessors	$1,085
LAAS	$3,367
AWOS	$23,934
OPS PROCEDURES AND CERTIFICATION	**$1,515**
TOTAL COSTS	**$87,915**

Cost Results-AK
GA/Commercial Avionics Equipage Costs

Current Year -$K	UAT DATALINK						
	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY2007-FY2011	Total
General Aviation/Commercial Aircraft							
Equipage Quantity	**750**	**750**	**750**	**750**	**750**	**100**	**3850**
Equipage Costs	**$15,715**	**$16,677**	**$17,565**	**$18,483**	**$19,432**	**$18,170**	**$106,043**
System Equipment	$12,900	$13,171	$13,448	$13,730	$14,018	$15,927	$69,176
System Installation	$2,815	$2,874	$2,934	$2,996	$3,059	$3,475	$15,093
Additional System Costs		$632	$1,183	$1,757	$2,355	$18,201	$21,774

FAA CIP vs. Required F&E Funding

- FAA CIP vs Required F&E Funding
- Ohio River Valley Detailed CIP Impacts
- Alaska Detailed CIP Impacts
- Alaska Detailed CIP Impacts - System Buy Schedule

FAA CIP vs. Required F&E Funding Current Year $K

Current Year $K	FY02	FY03	FY04	FY05	FY06	Total
OHIO						
CIP	$10,000	$10,000	$10,000	$9,700	$3,000	**$42,700**
Required	$14,816	$11,415	$10,275	$9,741	$3,449	**$49,696**
Delta	-$4,816	-$1,415	-$275	-$41	-$449	**-$6,996**
CAPSTONE						
CIP	$15,000	$10,000	$5,000	$5,300	$2,000	**$37,300**
Required	$21,097	$20,504	$21,080	$19,386	$3,055	**$85,121**
Delta	-$6,097	-$10,504	-$16,080	-$14,086	-$1,055	**-$47,821**

FAA CIP vs. Required F&E Funding-ORV
Detailed CIP Impacts - Current Year $M

Cost Element	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	Total
GROUND INFRASTRUCTURE	**$4.7**	**$2.8**	**$0.8**	**$0.5**		**$8.8**
ADS-B Ground Stations - En Route	$1.0	$1.1	$0.2	$0.1		$2.3
ADS-B/Multilateration Systems - Terminal	$3.5	$1.6	$0.4	$0.4		$5.9
Vehicle ADS-B	$0.2	$0.2	$0.2			$0.6
AVIONICS DEVELOPMENT						
AUTOMATION INTERFACE	**$0.9**					**$0.9**
Multiprocessor - En Route	$0.5					$0.5
Multiprocessor - Terminal	$0.4					$0.4
Displays	$0.1					$0.1
FIS-B DEVELOPMENT/AUTOMATED WEATHER						
SOFTWARE CHANGES			**$2.5**	**$2.1**		**$4.6**
TIS-B DEVELOPMENT		**$2.5**	**$1.0**	**$1.0**		**$4.5**
NASA AMES	**$0.8**	**$0.5**	**$0.5**	**$0.5**	**$0.1**	**$2.4**
ORV PROGRAM OFFICE	**$3.6**	**$3.4**	**$4.1**	**$4.2**	**$2.2**	**$17.5**
REGIONAL/TECH CENTER SUPPORT		**$0.8**	**$1.1**	**$1.4**	**$0.7**	**$4.0**
CIP Profile	**$10.0**	**$10.0**	**$10.0**	**$9.7**	**$3.0**	**$42.7**
CIP Funding	$10.0	$10.0	$10.0	$9.7	**$3.0**	**$42.7**
Delta	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**

Additional Requirements	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	Total
AVIONICS DEVELOPMENT	**$1.0**					**$1.0**
FIS-B DEVELOPMENT/AUTOMATED WEATHER	**$2.0**					**$2.0**
NASA AMES					**$0.4**	**$0.4**
ORV PROGRAM OFFICE	**$0.5**	**$0.8**				**$1.3**
REGIONAL/TECH CENTER SUPPORT	**$1.3**	**$0.6**	**$0.3**			**$2.2**
Total Required Funding	**$14.8**	**$11.4**	**$10.3**	**$9.7**	**$3.4**	**$49.6**
CIP Funding	$10.0	$10.0	$10.0	$9.7	$3.0	**$42.7**
Delta	**-$4.8**	**-$1.4**	**-$0.3**	**$0.0**	**-$0.4**	**-$6.9**

FAA CIP vs. Required F&E Funding-AK
Detailed CIP Impacts - Current Year $M

Phased Annual Costs-Current Year $M	**UAT DATALINK**					
Cost Element	**FY 2002**	**FY 2003**	**FY 2004**	**FY 2005**	**FY 2006**	**Total**
SURFACE REQUIREMENTS	**$13.7**	**$8.9**	**$3.8**	**$3.8**	**$1.1**	**$31.2**
Ground Broadcast Transceivers	$8.5	$8.1	$3.3	$3.3	$1.1	$24.4
Multiprocessor	$0.9					$0.9
LAAS	$2.4	$0.0				$2.4
AWOS	$0.7	$0.1				$0.8
Vehicle ADS-B	$1.2	$0.7	$0.5	$0.4		$2.8
AUTOMATION REQUIREMENTS	**$0.5**	**$0.5**	**$0.5**	**$0.6**		**$2.2**
CAPSTONE PROGRAM OFFICE SUPPORT	**$0.8**	**$0.7**	**$0.7**	**$0.9**	**$0.9**	**$3.9**
CIP Profile	**$15.0**	**$10.0**	**$5.0**	**$5.3**	**$2.0**	**$37.3**
CIP Funding	$15.0	$10.0	$5.0	$5.3	$2.0	$37.3
Delta	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**

Additional Requirements	**FY 2002**	**FY 2003**	**FY 2004**	**FY 2005**	**FY 2006**	**Total**
SURFACE REQUIREMENTS	**$6.1**	**$10.4**	**$15.9**	**$14.1**	**$1.1**	**$47.6**
Ground Broadcast Transceivers		$2.1	$7.7	$6.2	$0.6	**$16.7**
Multiprocessor		$0.9	$0.9	$0.9		**$2.7**
LAAS		$2.4	$2.4	$2.5	$0.1	**$7.4**
AWOS	$6.1	$4.8	$4.9	$4.5	$0.4	**$20.7**
Vehicle ADS-B		$0.1				**$0.1**
AUTOMATION REQUIREMENTS						
CAPSTONE PROGRAM OFFICE SUPPORT		**$0.1**	**$0.1**			**$0.3**
Total Required Funding	**$21.1**	**$20.5**	**$21.1**	**$19.4**	**$3.1**	**$85.1**
CIP Funding	$15.0	$10.0	$5.0	$5.3	$2.0	$37.3
Delta	**-$6.1**	**-$10.5**	**-$16.1**	**-$14.1**	**-$1.1**	**-$47.8**

FAA CIP vs. Required F&E Funding-AK
Detailed CIP Impacts - System Buy Schedule

	UAT DATALINK					
System Buy Quantities	**Prior Years**	**FY 2002**	**FY 2003**	**FY 2004**	**FY 2005**	**Total**
SURFACE REQUIREMENTS						
Ground Broadcast Transceivers	13	50	39	12	14	128
Multiprocessor	1	3				4
LAAS	1	3				4
AWOS	14	1				15
Vehicle ADS-B	150	470	230	150	138	1138
AUTOMATION REQUIREMENTS	n/a	n/a	n/a	n/a	n/a	
CAPSTONE PROGRAM OFFICE SUPPORT	n/a	n/a	n/a	n/a	n/a	

Additional Requirements	**Prior Years**	**FY 2002**	**FY 2003**	**FY 2004**	**FY 2005**	**Total**
SURFACE REQUIREMENTS						
Ground Broadcast Transceivers			11	38	24	73
Multiprocessor			3	3	3	9
LAAS			3	3	3	9
AWOS		11	8	8	7	34
Vehicle ADS-B			40			40
AUTOMATION REQUIREMENTS	n/a	n/a	n/a	n/a	n/a	
CAPSTONE PROGRAM OFFICE SUPPORT	n/a	n/a	n/a	n/a	n/a	

Conclusion

- Status:
  - Major cost drivers captured
  - Refining/updating of estimate on-going

- Issues and Concerns
  - Certification
  - Operational Concept
  - System Architecture

Introduction to Benefits

Enhancement 1: FIS-B Results

Safe Flight 21

Enhancement 1 FIS-B

February 28, 2000

Weather Related Accident Facts

- Weather is a major cause of fatal GA accidents
- 1998 Nall report cites that 82.6 percent of fatal weather related accidents were caused by attempted VFR into IMC conditions.
  - In 1997, 98.8% of the hours flown in AK were in VMC conditions
  - Other factors are conducting operations
    - in thunderstorm areas
    - in structural icing conditions
    - in areas of turbulence
- From 1989 to 1998, 26.4 percent of accidents were weather related -- in Alaska the percentage of weather related accidents was 29.7.
- It is estimated that between 25 to 30% of all fatal accidents involve weather decision making.
  - In a very large percentage of these cases, a causal factor is that the pilot was unaware of a weather hazard area.

Weather and Other Info to the Cockpit

- Flight Information Service (FIS)
  - Will provide pilots with real-time, one way airborne access to weather information as text or graphic displays of ground-based weather radar and other national products
    - Weather displays in relation to aircraft while in flight
    - Provides options to avoid severe weather
- Service available in early 2000 or by the Summer
- Vendors will obtain services from the National Weather Service
  - NEXRAD
  - METARs
  - TAFs
- Weather data not tailored to regions

WX-Related Accidents Versus All Accidents CONUS & Alaska

Year	Total AK Accidents	AK Weather Accidents	Percentage of AK Weather Related Accidents to Total Accidents	Total Accidents	Weather Accidents	Percentage of Weather Related Accidents to Total Accidents
1989	188	66	35.1%	2389	721	30.2%
1990	191	55	28.8%	2361	626	26.5%
1991	163	46	28.2%	2306	595	25.8%
1992	177	58	32.8%	2195	596	27.2%
1993	174	37	21.3%	2144	533	24.9%
1994	133	36	27.1%	2108	465	22.1%
1995	170	56	32.9%	2146	557	26.0%
1996	156	49	31.4%	2025	574	28.3%
1997	150	43	28.7%	1708	444	26.0%
Total	**1502**	**446**	**29.7%**	**19382**	**5111**	**26.4%**

	Total Accident	Total Fatal	Fatalities	Percent Fatal	Avg fatalities per fatal accident	Avg fatalities per accident
Alaska -- All Accidents	1502	192	394	12.8%	2.05208	0.26232
Alaska -- WX Accidents	446	72	167	16.1%	2.31944	0.37444

- ***Alaska has a 3.3 percent higher rate than the national rate of weather related accidents (on average)***

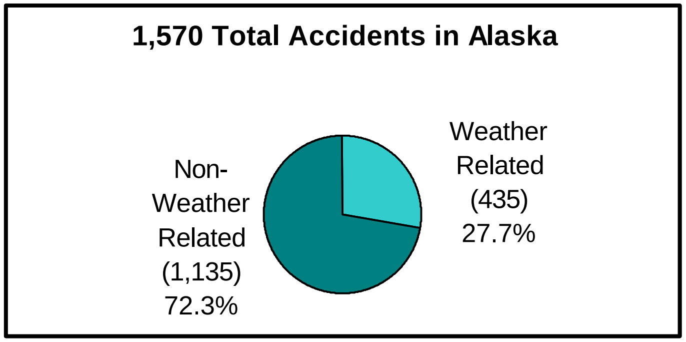
Accident Rates for CONUS and AK

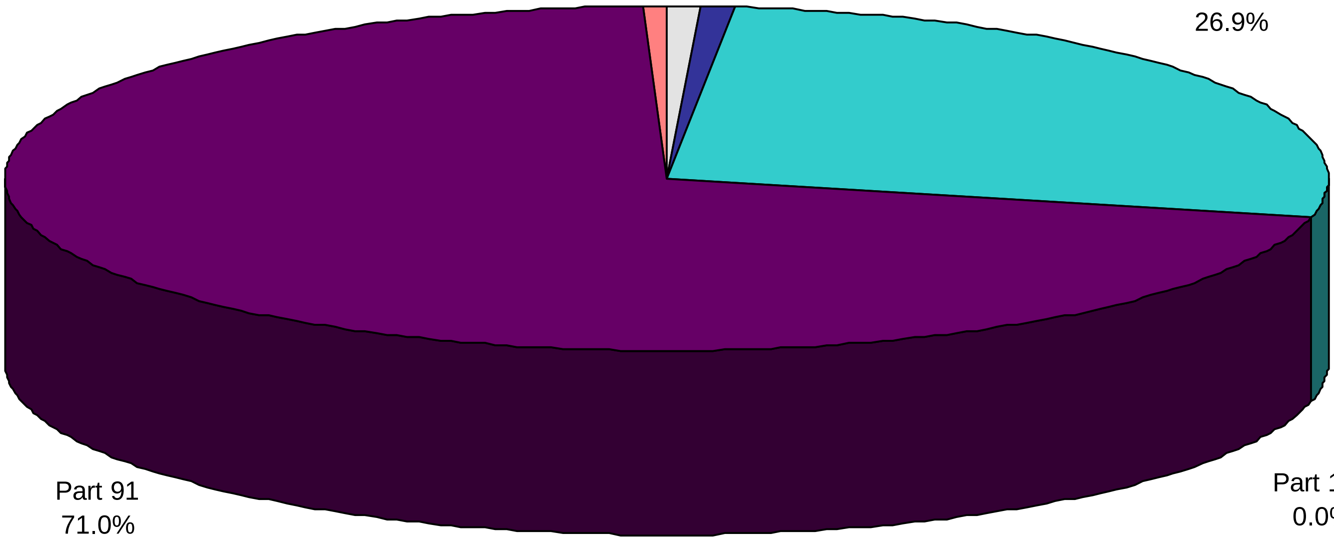
YEAR	SumOfT_AOPS	Accidents	Accidents per 100000 Ops	Weather Accidents	Weather Accidents per 100000 Ops
1989	122993686	2389	1.9424	721	0.5862
1990	125266495	2361	1.8848	626	0.4997
1991	122087268	2306	1.8888	595	0.4874
1992	121449765	2195	1.8073	596	0.4907
1993	119764996	2144	1.7902	533	0.4450
1994	119296995	2108	1.7670	465	0.3898
1995	118256923	2146	1.8147	557	0.4710
1996	120294540	2025	1.6834	574	0.4772
1997	119436721	1708	1.4300	444	0.3717
Total 1989 to 1997	**1088847389**	**19382**	**1.7800**	**5111**	**0.4694**

Both Accident Rate and Weather-Related Accident rate are significantly higher in Alaska (7.98 per 100000 ops versus 1.78 and 2.37 versus 0.46)

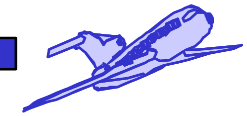
YEAR	All Ak T_AOPS	AK Accidents	Ak Accidents per 100000 Ops	Ak Weather Accidents	Ak Weather Accidents per 100000 Ops
1989 Total	2010685	188	9.350	66	3.2825
1990 Total	2036475	191	9.379	55	2.7007
1991 Total	1990738	163	8.188	46	2.3107
1992 Total	2007872	177	8.815	58	2.8886
1993 Total	1516577	174	11.473	37	2.4397
1994 Total	1952707	133	6.811	36	1.8436
1995 Total	1993514	170	8.528	56	2.8091
1996 Total	2714462	156	5.747	49	1.8051
1997 Total	2580351	150	5.813	43	1.6664
Total 1989 to 1997	**18803381**	**1502**	**7.98793**	**446**	**2.3719139**

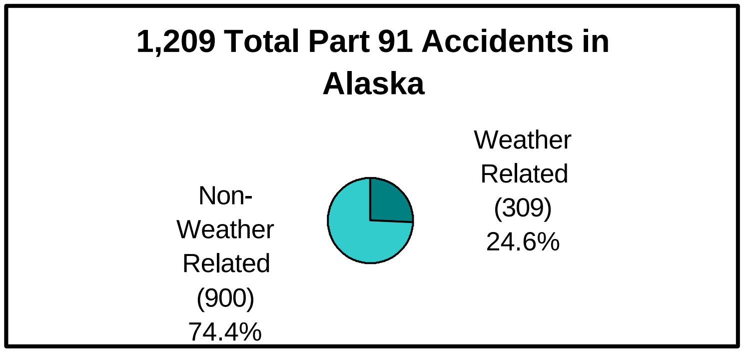
Weather Study: NTSB Weather Related Accident By FAR Part 1989 to 1998

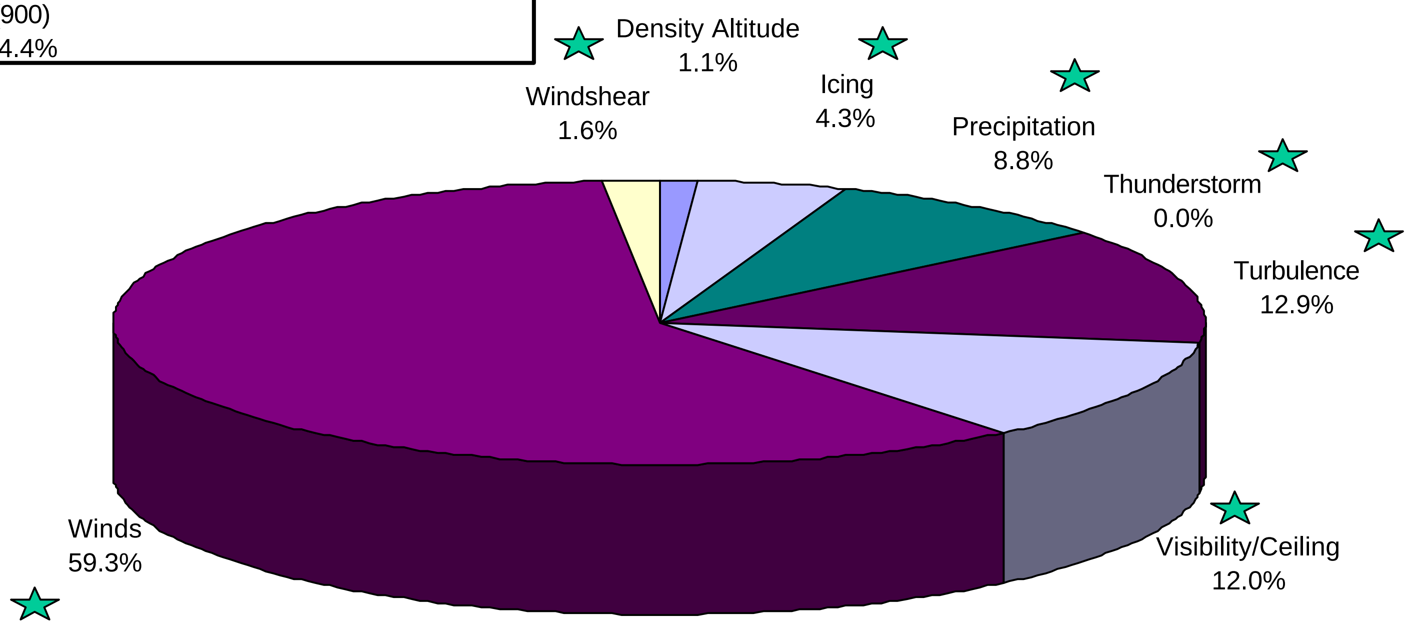




Weather Study: Distribution of NTSB Part 91 Accidents by Weather Related Findings 1989 to 1998



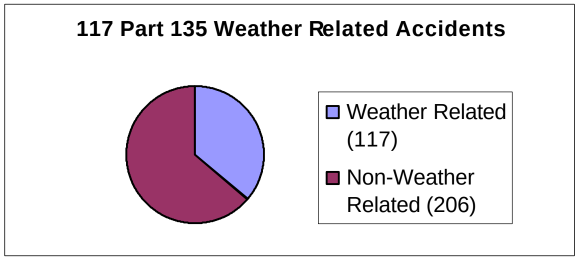


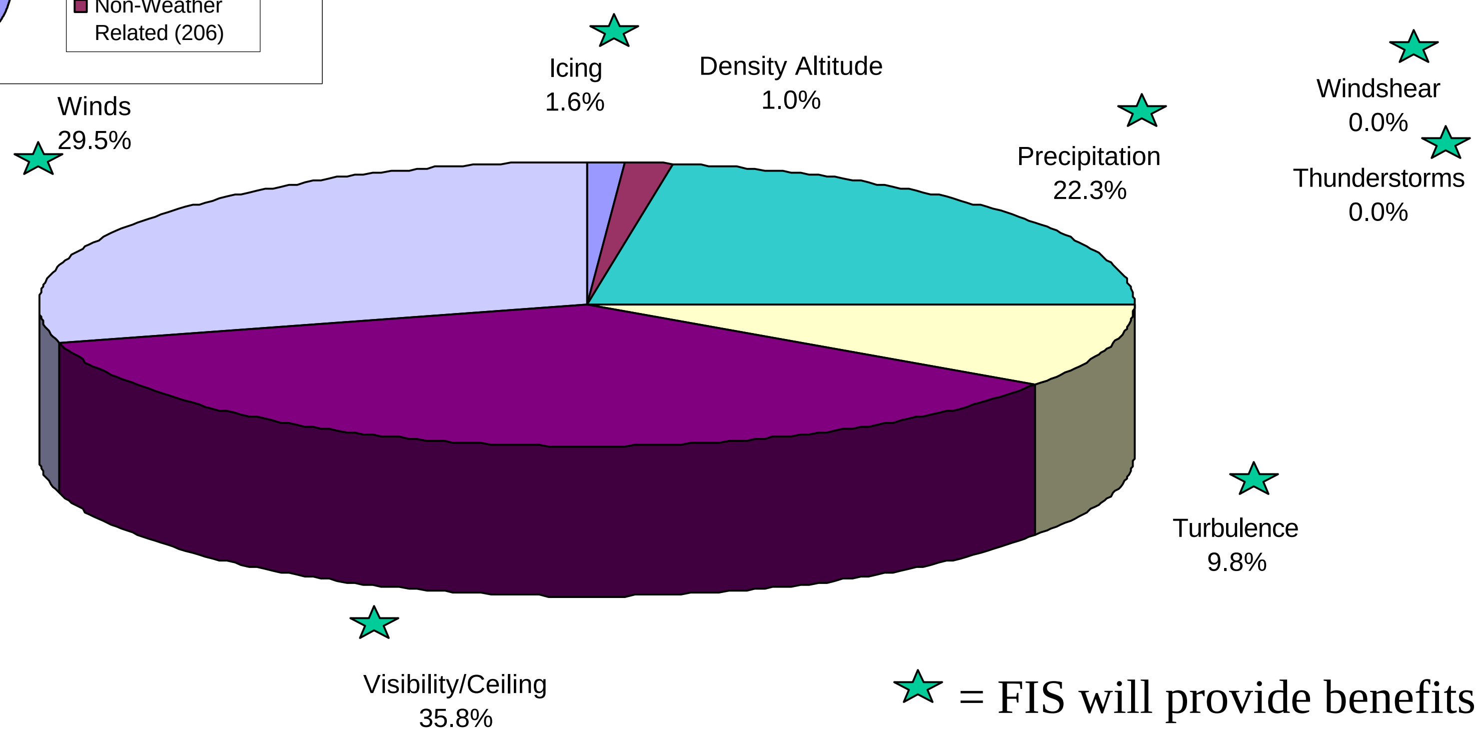


★ = FIS will provide benefits

* for each case the benefits will apply for some portion of aircraft operations

Weather Study: Distribution of NTSB Part 135 Weather Related Accidents 1989 to 1998





= FIS will provide benefits

* for each case the benefits will apply for some portion of aircraft operations

FIS-B Assumptions

CONUS less AK

YEAR	Equippage Rate	Air carrier w/out	Air Taxi	GA	total
2002	6%				
2003	11%				
2004	17%	Total Weather Accidents 1989 to 1997			
2005	23%	75	317	3665	4057
2006	29%				
2007	34%				
2008	40%	**Weather Accidents per 100000 ops**			
2009	46%	0.0638	0.2859	0.4619	
2010	52%	**CFIT potion - accidents per 100000 ops**			
2011	57%	-	0.034	0.035	
	Effectiveness	**Cost per Accident**			
	0.25	$ 4.14	$ 3.7	$ 1.8	

Alaska

YEAR	Equippage Rate	Air carrier w/out	Air Taxi	GA	total
2002	13%				
2003	24%				
2004	35%	Total Accidents in Alaska 1989 to 1997			
2005	45%	3	121	309	433
2006	56%				
2007	57%				
2008	56%	**WX Accidents per 100000 ops**			
2009	56%	0.1982	1.7608	3.1205	
2010	56%	**CFIT portion -accidents per 100000 ops**			
2011	55%	-	0.513	0.831	
	Effectiveness	**Cost per Accident**			
	0.25	$ 3.03	$ 2.41	$ 0.98	

- *Accident, injury / damage rates, and fleet mix are based on analysis of NTSB accidents*
- *63% of CFIT accidents involve weather. Those accidents are removed from the FIS-B benefits pool.*

Safety: Enhancement 1 - FIS-B

- It is assumed that FIS-B and CFIT share a portion of the CFIT benefits pool.
  - 63% of CFIT accidents involve weather. To avoid double counting, they are not counted here but are considered under CFIT benefits
- Equipage for FIS-B will be mainly for Part 91 and 135 aircraft.
- FIS-B effectiveness would prevent 25% of weather accidents

Weather Safety Benefits (2002-2011)

	Constant $M	LD: AK	NAS
	Benefits Pool	$ 896	$ 9,438
Minus	Existing/Planned Capabilities	$ 609	$ 2,916
Equal	Remaining Pool	$ 287	$ 6,522
	Effectiveness (25%)	$ 72	$ 1,630
	Equipage Factor	$ 33	$ 518

* Benefits Pool Overlaps with CFIT Ben Pool

* Benefits for NAS do not include AK - they are additive

Enhancement 1: Weather Accident Data Review

WN-9701/021-04

Safe Flight 21 Program

Weather Accident Data Review

28 January 2000

SF21

Outline

- Purpose
- Data Collection
- Background
  - Problem Description
  - Current Initiatives
- Weather-Related Accident Data
  - Overview
  - Air Carrier Accidents
  - General Aviation Accidents
  - Part 135 Commuter/Air Taxi Accidents
- Alaska Weather-Related Accidents
  - Entire Region
  - Bethel
- Summary

Purpose

- Provide a description of the need for improving cockpit weather information and identify current initiatives
- Provide an overview of weather-related accidents
  - Overall magnitude of weather-related accidents
    - Weather-related accidents as a percentage of total accidents
    - Fatalities, injuries, and aircraft damage due to weather
  - Impact of different weather phenomena on individual operation categories
    - Weather types most predominately cited in accidents for each operation category
    - Characteristics of weather-related accidents for each operation category
- Provide an overview of weather-related accidents occurring in Alaska

Data Collection

- *Weather-Related Accidents by Category of Operation 1989 through 1998*, NASDAC
- *Review of Scheduled 121/129 Clear Air Turbulence Accidents*, MCR Federal Inc.; September 1999
- *Historical Safety Impact of Turbulence*, MCR Federal Inc.; June 1999
- *Safer Skies: A Focused Safety Agenda*, General Aviation Weather Joint Safety Analysis Team; April 1999
- *AWARE: Technologies for Interpreting and Presenting Aviation Weather Information*, Rockwell Science Center; March 1999
- *Historical Overview of In-Flight Icing Accidents*, MCR Federal, Inc.; January 1999
- *Aviation Safety -FAA has not Fully Implemented Weather-Related Recommendations*, GAO; June 1998

Data Collection (Cont'd)

- *Turbulence Education and Training Aid*, Flight Crew View, US Airways; June 1998
- *General Aviation Weather Accidents 1982 through 1983*, AOPA Air Safety Foundation; 1996
- *Aviation Weather Services, A Call for Federal Leadership and Action*, NRC; 1995
- *Cockpit Graphical Weather Information Shown to Enhance Efficiency, Safety and Situation Awareness*, NASA Langley Research Center
- NTSB Weather-Related Accident Reports 1987 through 1996
  - Alaska Accidents
  - Part 121 Fatal Accidents

Background Problem Description

- Providing quality and accessible weather information to pilots inflight cited as a primary unmet user need by several sources
  - National Aviation Weather Program Plan
  - National Research Council
  - GAO
  - General Aviation Weather Joint Safety Analysis Team (JSAT)

- FAA urged to improve the access to advanced aviation weather products
  - Graphic weather products
  - Ground-to-air communications and cockpit display systems
  - Enhanced weather observations and forecasts

Background Problem Description (Cont'd)

- General Aviation Weather JSAT identified cockpit weather recommendations as first-priority interventions
  - Greatest potential for preventing an accident
  - Greatest possibility for wide implementation

- Limitations of current weather services available to General Aviation
  - Preflight
    - Provide weather information for too large areas
    - Does not provide flight-specific weather information
    - Visual information via NEXRAD not correlated to textual information
  - En Route
    - Pilot does not have access to much of the raw data available preflight
    - Limited to sparse information via voice links or whatever is visible outside windshield

Background Current Initiatives

- Research is currently being conducted to improve cockpit weather information
  - Flight Information Service (FIS)
    - Graphical Weather Service (GWS)
    - Terminal Weather Information for Pilots (TWIP)
  - Cockpit Weather Information (CWIN)
  - Aviation Weather Information (AWIN)

Background Current Initiatives (Cont'd)

- Flight Information Service (FIS)
  - Includes the following capabilities:
    - Traffic Information Service (TIS)
    - Terminal Weather Information for Pilots (TWIP)
    - Cockpit Display of Traffic Information (CDTI)
    - Graphical Weather Services (GWS)
  - Enables pilots to access weather information in flight with a touch of a button via data link
  - General Aviation Weather JSAT requires deployment completed by June 2000
  - Benefits include enhanced situational awareness and safety

Background Current Initiatives (Cont'd)

- Graphical Weather Service (GWS)
  - Demonstration project at Frederick, MD
    - Uses commissioned Mode S sensor at Dulles International Airport
    - Aircraft provided by AOPA using prototype commercial avionics
  - Real-time nationwide precipitation mosaic presented on a cockpit display unit
  - Can be expanded to include other graphical data
  - Range options of 25, 50, 100 and 200 nautical miles

Background Current Initiatives (Cont'd)

- Terminal Weather Information for Pilots (TWIP)
  - Provides ground-based terminal weather information to pilots via data link
  - Products include the following:
    - Descriptions and depictions of airport weather
    - Convective activity within 15 nautical miles of the terminal area
    - Expected weather that will impact airport operations
  - Uses data from the Terminal Doppler Weather Radar (TDWR) or the Integrated Terminal Weather System (ITWS)

Background Current Initiatives (Cont’d)

- Cockpit Weather Information (CWIN)
  - Piloted simulation and flight test research program being conducted by NASA Langley Research Center
  - Provides graphical weather presentations to flight crews during flight
  - Pilot simulation tests indicated benefits
    - En Route weather avoidance- flight crews flew 5% shorter enroute segments and burned 5% less fuel when using CWIN
    - Safety of flight - flight crews cleared thunderstorm cells by three times the distance when they used CWIN
    - Weather situational awareness - pilot ratings showed CWIN to be much better for situational awareness

Background Current Initiatives (Cont'd)

- Aviation Weather Information (AWIN)
  - Consortium led by Boeing and NASA Langley Research Center
  - Extension of the CWIN program
  - Provides real-time data link capabilities and real-time weather information
  - Preliminary evaluation using a FedEx MD-11 will be complete in first quarter of 2000
  - Benefits include improved situational awareness during pre-flight and en-route planning

Weather-related Accident Data Overview

- NTSB uses many weather modifiers to specify conditions attributing to an accident
  - Weather cited as either a cause or contributing factor
  - More than one weather modifier may be listed per accident

- NASDAC groups NTSB weather modifiers into the following categories:
  - Density Altitude
  - Icing
  - Precipitation
  - Thunderstorm
  - Turbulence
  - Visibility/Ceiling
  - Wind/Windshear

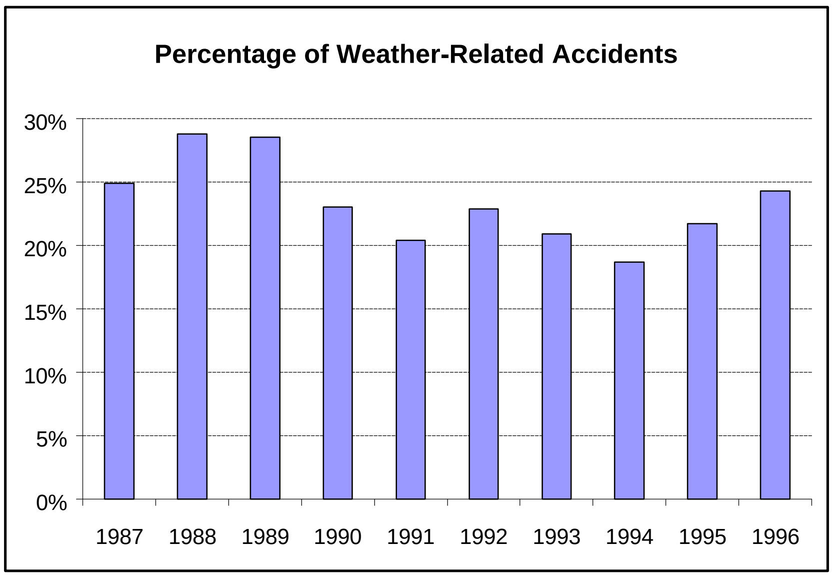
NASDAC Grouping	Code	Description
DENSITY ALTITUDE	2212	HIGH DENSITY ALTITUDE
DENSITY ALTITUDE	2223	TEMPERATURE EXTREMES
DENSITY ALTITUDE	2234	NO THERMAL LIFT (gliders/sailplanes)
DENSITY ALTITUDE	2235	THERMAL LIFT (gliders/sailplanes)
DENSITY ALTITUDE	2250	TEMPERATURE, HIGH
DENSITY ALTITUDE	2251	TEMPERATURE, LOW
DENSITY ALTITUDE	2252	TEMPERATURE INVERSION
ICING	2202	CARBURETOR ICING CONDITIONS
ICING	2213	ICING CONDITIONS
ICING	2233	ICE FOG
PRECIPITATION	2219	RAIN
PRECIPITATION	2220	SNOW
PRECIPITATION	2230	WHITEOUT
PRECIPITATION	2240	DRIZZLE
PRECIPITATION	2247	PRECIPITATION STATIC CONDITIONS
THUNDERSTORM	2208	HAIL
THUNDERSTORM	2215	LIGHTNING
THUNDERSTORM	2216	LIGHTNING STRIKE
THUNDERSTORM	2221	STATIC DISCHARGE
THUNDERSTORM	2228	THUNDERSTORM
THUNDERSTORM	2229	TORNADO
THUNDERSTORM	2238	MICROBURST/WET
THUNDERSTORM	2239	MICROBURST/DRY
THUNDERSTORM	2241	THUNDERSTORM LEVEL I
THUNDERSTORM	2242	THUNDERSTORM LEVEL II
THUNDERSTORM	2243	THUNDERSTORM LEVEL III
THUNDERSTORM	2244	THUNDERSTORM OUTFLOW

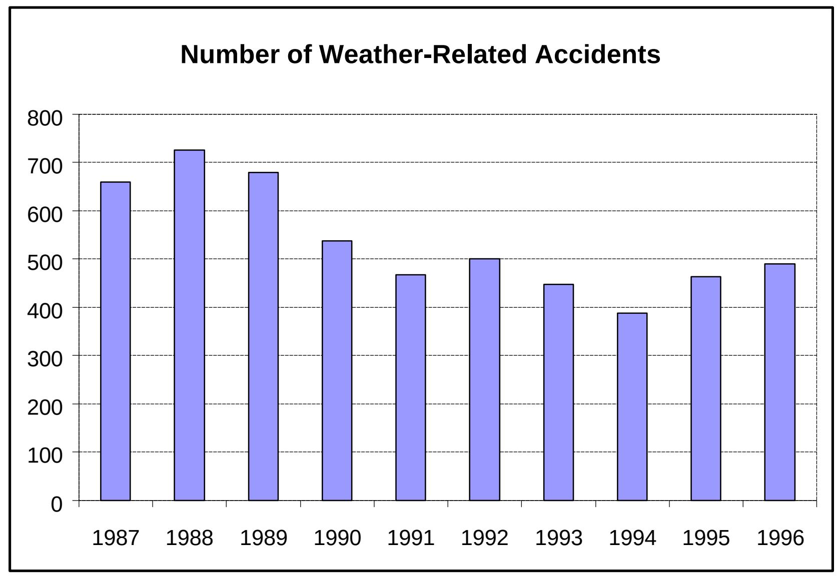
NASDAC Grouping	Code	Description
TURBULENCE	2205	DOWNDRAFT
TURBULENCE	2217	MOUNTAIN WAVE
TURBULENCE	2224	TURBULENCE
TURBULENCE	2225	TURBULENCE, CLEAR AIR
TURBULENCE	2226	TURBULENCE IN CLOUDS
TURBULENCE	2227	TURBULENCE (Thunderstorms)
TURBULENCE	2236	UPDRAFT
TURBULENCE	2253	TURBULENCE TERRAIN INDUCED
VISIBILITY/CEILING	2201	VISBILITY/RVR
VISIBILITY/CEILING	2204	CLOUDS
VISIBILITY/CEILING	2206	FOG
VISIBILITY/CEILING	2209	HAZE/SMOKE
VISIBILITY/CEILING	2214	LOW CEILING
VISIBILITY/CEILING	2218	OBSCURATION
VISIBILITY/CEILING	2237	SAND/DUST STORM
VISIBILITY/CEILING	2255	VOLCANIC ASH
VISIBILITY/CEILING	2306	SUNGLARE
WIND/WINDSHEAR	2203	CROSSWIND
WIND/WINDSHEAR	2207	GUSTS
WIND/WINDSHEAR	2210	HIGH WIND
WIND/WINDSHEAR	2211	HURRICANE
WIND/WINDSHEAR	2222	TAILWIND
WIND/WINDSHEAR	2231	WINDSHEAR
WIND/WINDSHEAR	2232	UNFAVORABLE WIND
WIND/WINDSHEAR	2245	DUST DEVIL/WHIRLWIND
WIND/WINDSHEAR	2249	SUDDEN WINDSHIFT
WIND/WINDSHEAR	2254	VARIABLE WIND

Weather-related Accident Data Overview (Cont'd)

- 23.5% of all accidents in the NTSB database between 1987 and 1996 are weather-related

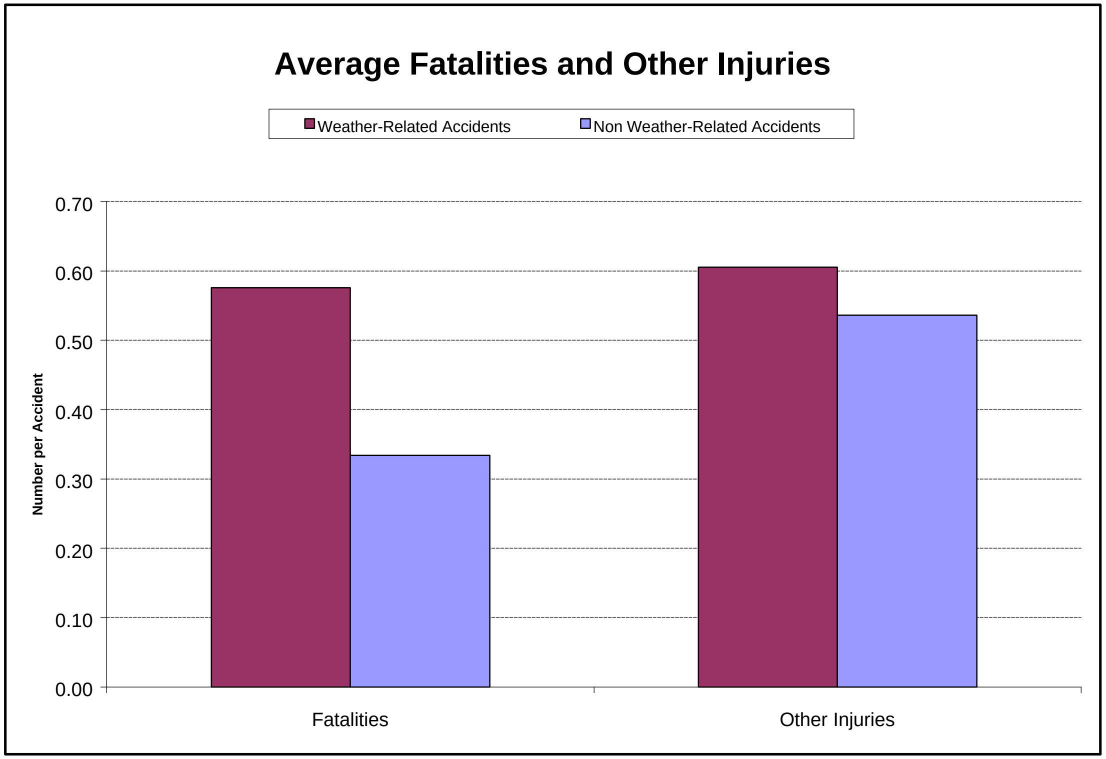
- Number of weather-related accidents has declined since the late-1980s





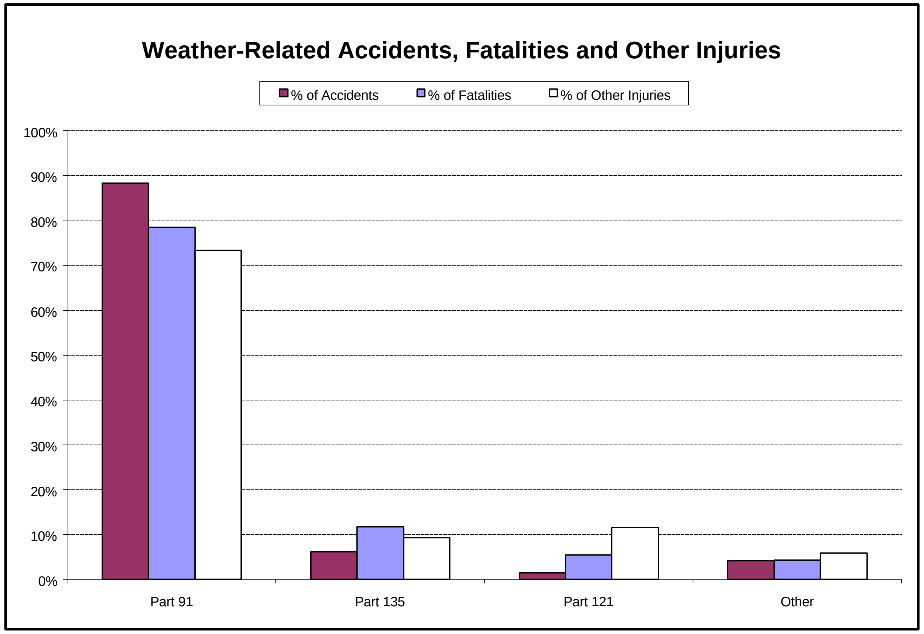
Weather-Related Accident Data Overview (Cont'd)

- Weather-related accidents result in a greater number of fatalities and injuries per accident than non weather-related accidents



Weather-Related Accident Data Overview (Cont'd)

- General Aviation account for 88.3% of all weather-related accidents and 78.5% of all weather-related fatalities
- Air Carriers account for only 1.4% of all weather-related accidents but 11.6% of all weather-related injuries

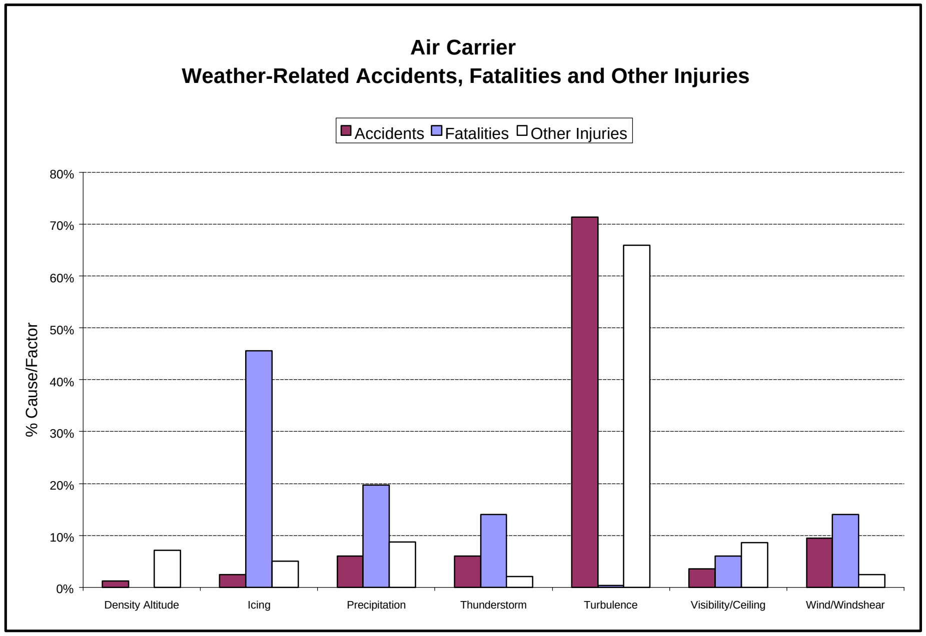


1987 to 1996	Part 91	Part 135	Part 121	Other	Total
# of Accidents	4,669	322	73	222	**5,287**
# of Fatalities	2,492	371	176	137	**3,176**
# of Other Injuries	2,345	298	372	186	**3,200**

* All metrics based on GAO study except Part 121 fatalities based on updated NTSB database search

Weather-Related Accident Data Air Carrier Accidents

- 30% of all Air Carrier accidents between 1987 and 1996 are weather-related
  - Icing is less than 3% of causes and factors cited in weather-related accidents but 45% in weather-related fatalities
  - Turbulence is 71% of causes and factors cited in weather-related accidents and 65% in weather-related injuries



Weather-Related Accident Data Air Carrier Accidents (Cont'd)

- 10 Air Carrier weather-related fatal accidents between 1987 and 1996
  - Greatest number of fatalities occurred due to in-flight icing at Roselawn, Indiana on 10/31/94
  - Current improvements in ground anti-icing/deicing capabilities have addressed accidents such as Denver and Flushing

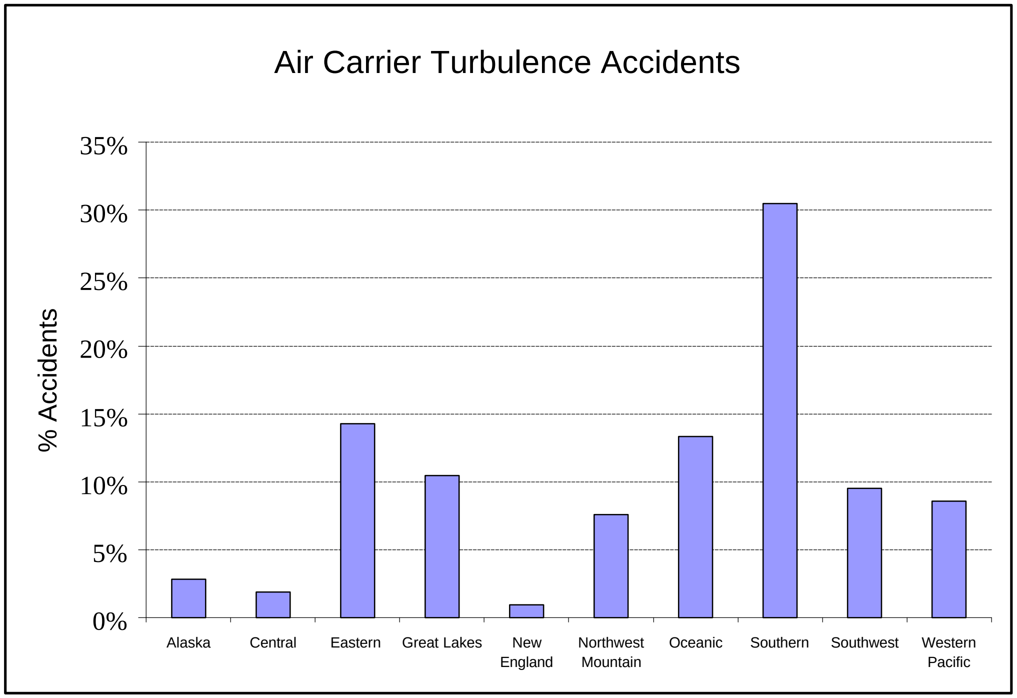
				Injury					
Date	**City**	**State**	**Phase of Flight**	**Fatal**	**Serious**	**Minor**	**None**	**Weather Categories**	**Description of Event**
10/31/94	Roselawn	IN	Holding	68	0	0	0	Icing	Loss of control due to accretion of ice beyond the deice boots
7/2/94	Charlotte	NC	Approach	37	16	4	0	Thunderstorm, Windshear	Missed approach due to thunderstorm & windshear. Lack of real-time adverse weather and windshear hazard information dissemination
3/22/92	Flushing	NY	Takeoff	22	9	12	3	Icing, Precipitation	Aerodynamic stall and loss of control after liftoff due to airframe icing. 35 minutes had elapsed between deicing and takeoff
2/15/92	Swanton	OH	Approach	4	0	0	0	Visibility/Ceiling	Missed approach due to unusual aircraft attitude that resulted from captain's apparent spatial disorientation
2/17/91	Cleveland	OH	Takeoff	2	0	0	0	Precipitation	Wing stall and loss of control during takeoff due to ice contamination on the airplane's wings
12/3/90	Romulus	MI	Takeoff	8	10	26	154	Visibility/Ceiling	Collison of aircraft in dense fog
10/3/90	Cape Canaveral	FL	Cruise	1	2	23	71	Turbulence	Encounter with thunderstorm turbulence. Passengers were not wearing seat belts
3/15/89	West Lafayette	IN	Approach	2	0	0	0	Icing	Loss of control due to undetected accumulation of ice on the leading edge of the horizontal stabilizer
11/15/87	Denver	CO	Takeoff	28	28	25	1	Icing, Precipitation	Aircraft stall during takeoff. 27 minutes had elapsed bewteen deicing and departure
4/13/87	Kansas City	MO	Approach	4	0	0	0	Visibility/Ceiling	Aircraft struck ground 3 miles short of runway. Aircraft approached at too low an altitude
Total				**176**	**65**	**90**	**229**		

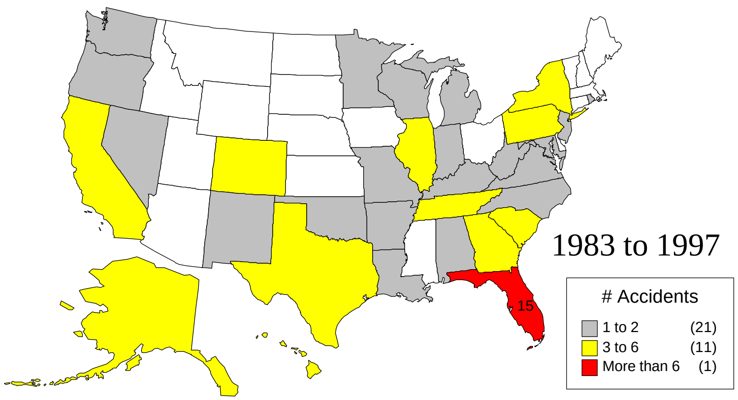
Weather-Related Accident Data Air Carrier Accidents (Cont'd)

- Turbulence most common cause of Air Carrier weather-related injuries
- Primary explanation for turbulence injuries is failure to be seated and properly secured while in flight
  - Less than 2% of serious injuries occurred while seated and belted
  - Flight attendants account for only 4% of occupants on flights but 53% of serious turbulence injuries
- 82% of turbulence accidents result in no aircraft damage

Weather-Related Accident Data Air Carrier Accidents (Cont'd)

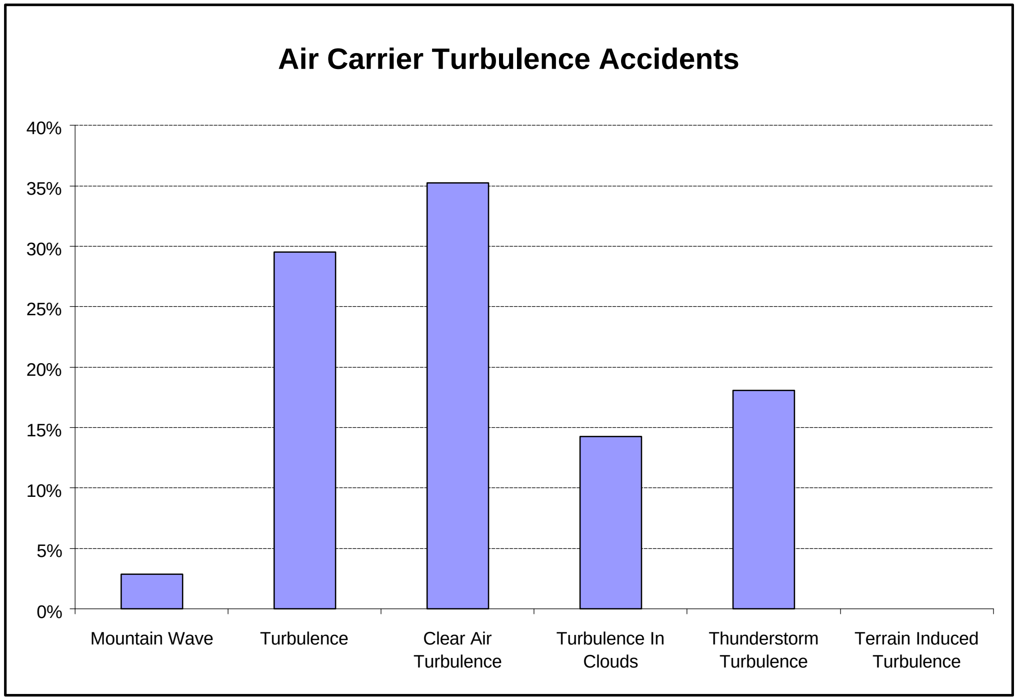
- Air Carrier turbulence accidents occur most frequently in the Southern region, but also occur relatively frequently in the Oceanic region





Weather-Related Accident Data Air Carrier Accidents (Cont'd)

- Clear Air Turbulence is the most common cause of Air Carrier turbulence accidents
  - 55% of the encounters are not forecast
  - 69% of the encounters occur over land and above 20,000 ft



* Does not include Updraft and Downdraft events

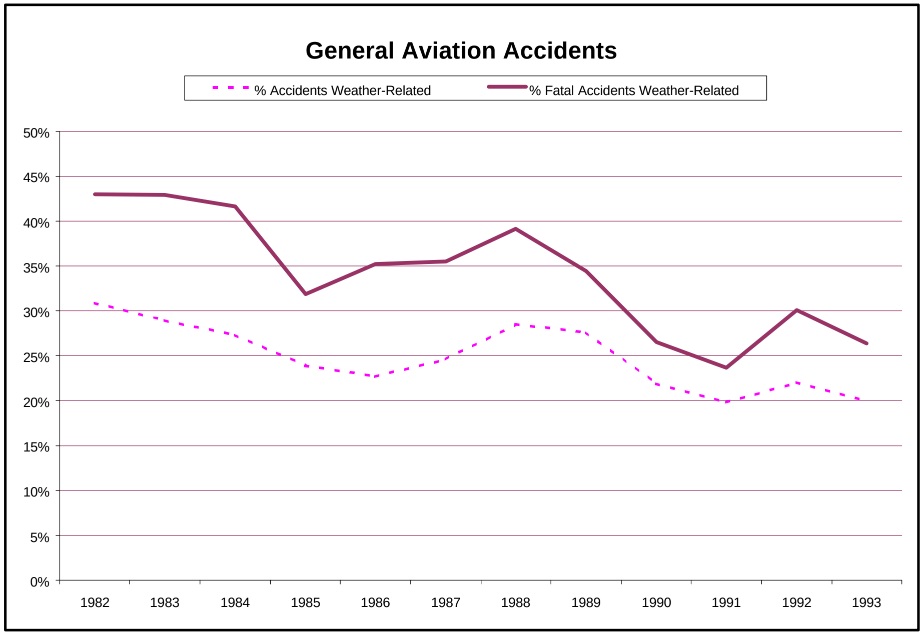
Weather-Related Accident Data Air Carrier Accidents (Cont'd)

- NTSB reports of turbulence may be understated
  - One major US airline reported 386 turbulence encounters resulting in injuries between 1994 and 1996
  - GAO cites a **total** of 372 Air Carrier weather-related NTSB accident reports between 1987 and 1996
  - 36 Air Carrier Clear Air Turbulence encounters reported in the Aviation System Reporting System (ASRS) between 1989 and 1998 that do not have corresponding NTSB report

- Vice President of American Airlines stated that more than 200 annual turbulence-related customer claims cost the company double-digit millions of dollars

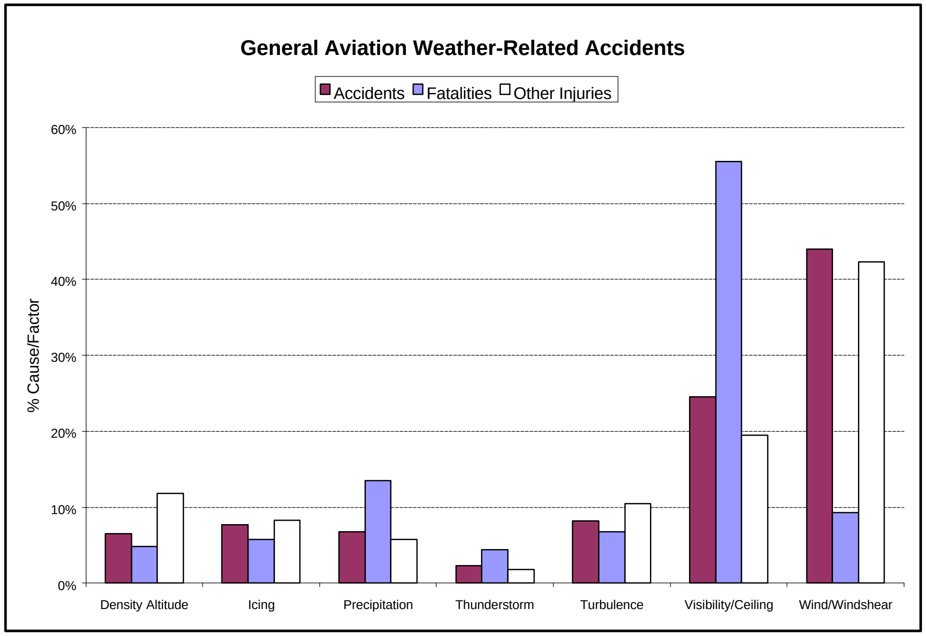
Weather-Related Accident Data General Aviation Accidents

- 24% of all General Aviation accidents between 1987 and 1996 are weather-related
- AOPA has compiled data from NTSB accident reports on all General Aviation weather accidents between 1982 and 1993
  - Weather involvement in all GA accidents has declined from 31% to 20%
  - Weather involvement in GA fatal accidents has declined from 43% to 26%



Weather-Related Accident Data General Aviation Accidents (Cont'd)

- Wind/Windshear is more than 40% of causes and factors cited in General Aviation weather-related accidents and injuries but less than 10% in weather-related fatalities
- Visibility/Ceiling is 24% of causes and factors cited in General Aviation weather-related accidents but 55% in weather-related fatalities



SF21

Preliminary Results

Weather-Related Accident Data General Aviation Accidents (Cont'd)

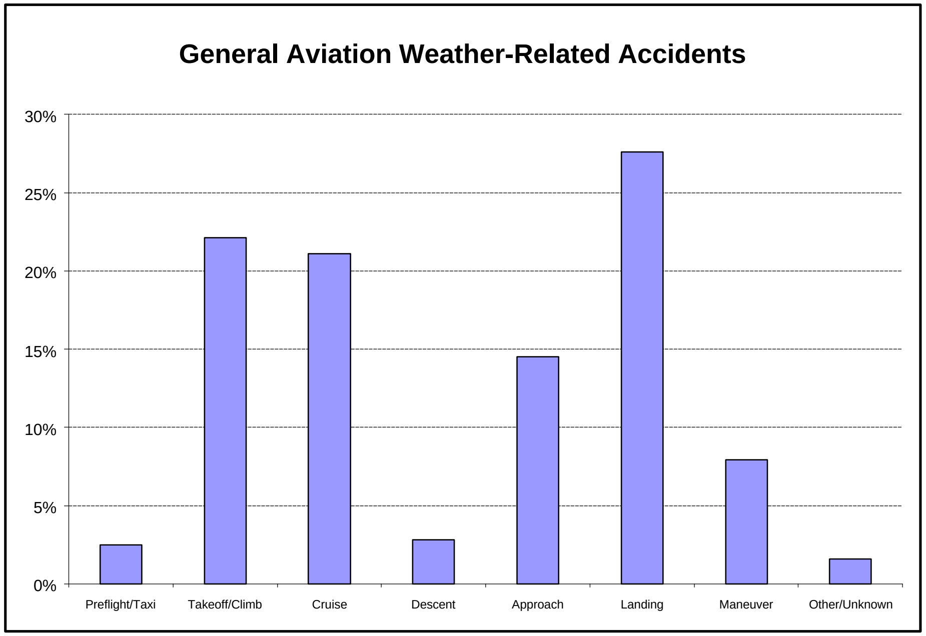
- 30% of General Aviation weather-related accidents are fatal
  - Wind has the lowest percentage of fatal accidents
  - Visibility or convective weather has the highest percentages of fatal accidents
  - Attempting VFR flight under conditions of deteriorating weather and dark nights is the prime cause of fatal weather accidents
    - Pilots fail to seek proper weather information
    - Pilots unable to understand weather information provided to them

AOPA Weather Category	Percentage of Accidents*	Percentage Fatal
Wind	48%	8%
Low Visibility	16%	58%
Fog	16%	65%
Low Ceiling	15%	61%
VFR into IMC	10%	82%
Density Altitude	9%	24%
Rain	7%	62%
Snow	5%	38%
Carburetor Icing	5%	11%
Airframe Icing	5%	43%
Thunderstorm	3%	66%

* More than one cited per accident

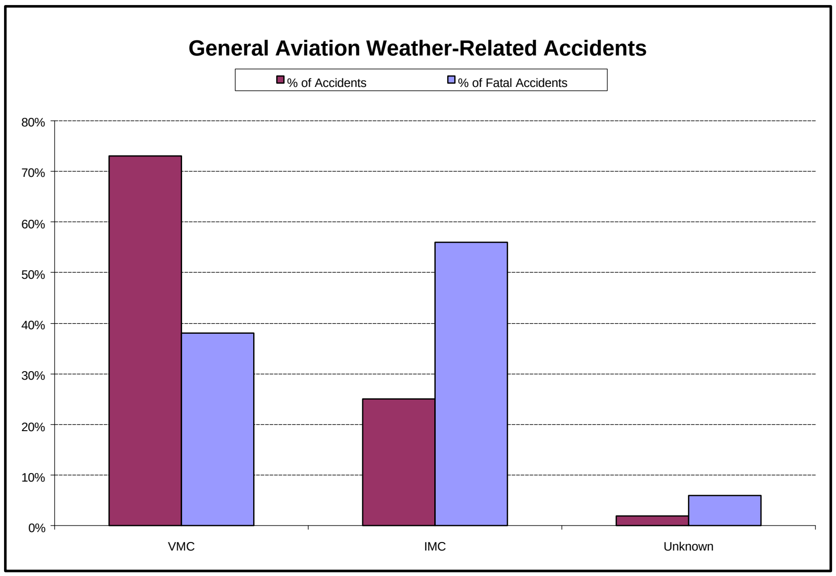
Weather-Related Accident Data General Aviation Accidents (Cont'd)

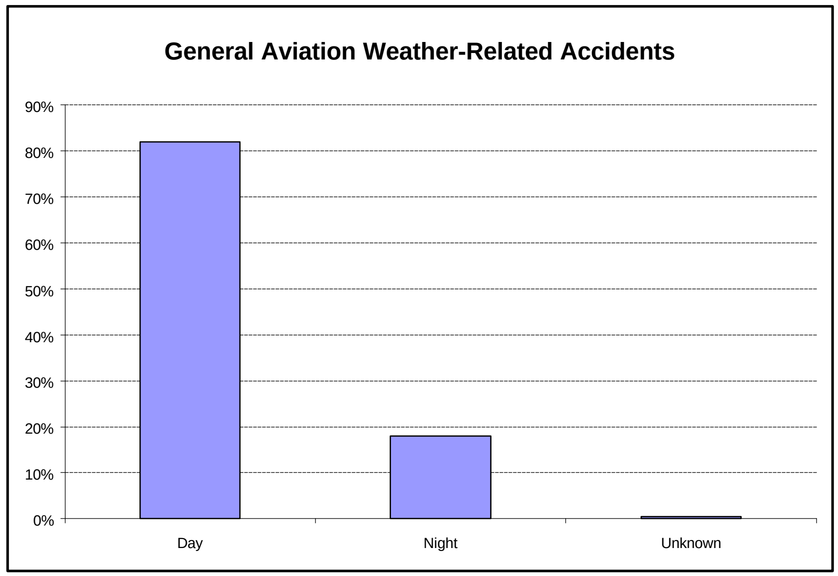
- Highest percentage of weather-related accidents occur during landing
  - Accidents involving wind, which constitute the most common weather cause of General Aviation accidents, occur most frequently during landing
  - Accidents involving other weather types occur most frequently during cruise



Weather-Related Accident Data General Aviation Accidents (Cont'd)

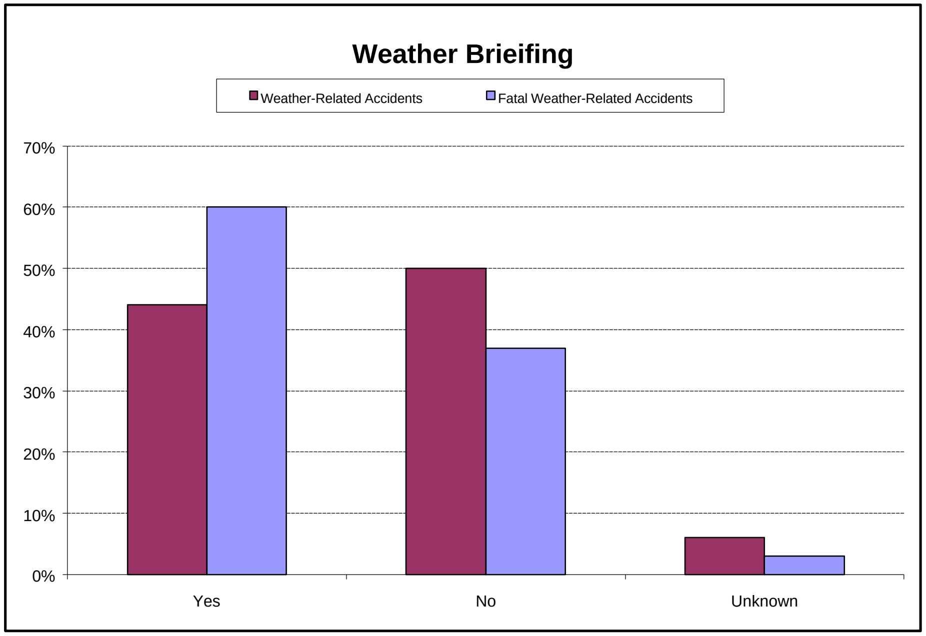
- Vast majority of weather-related accidents occur in day VMC conditions
  - 95% of wind accidents occur during VMC
  - Majority of fatal accidents occur during IMC





Weather-Related Accident Data General Aviation Accidents (Cont'd)

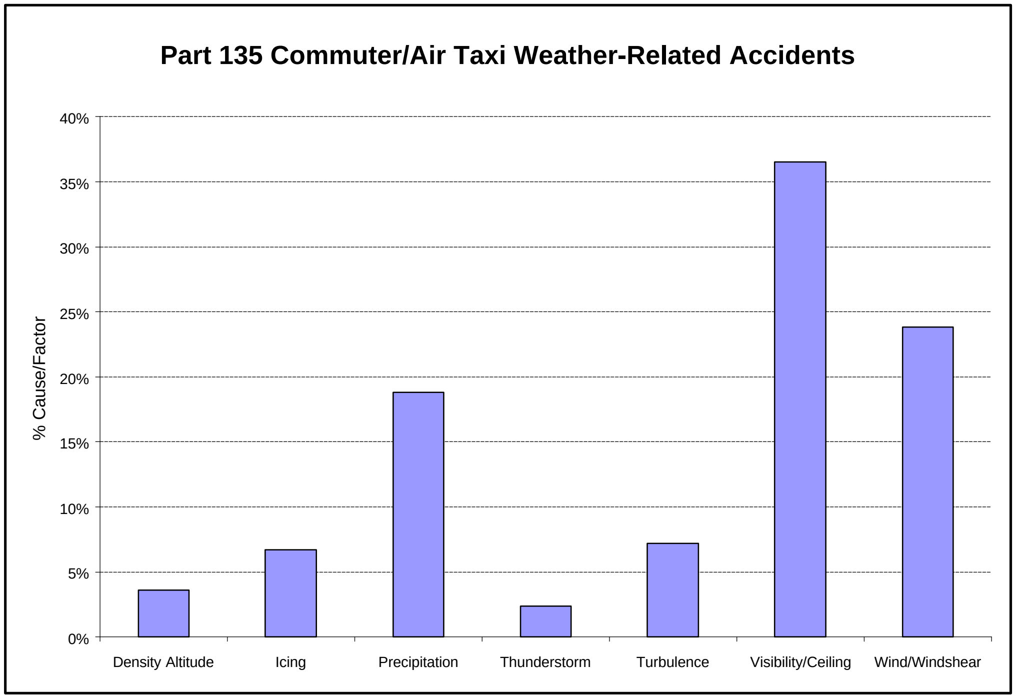
- 50% of pilots in General Aviation weather-related accidents do not request a weather briefing
  - 37% of pilots in General Aviation weather-related fatal accidents do not request a weather briefing
  - 33% of pilots in VFR-into-IMC accidents do not request a weather briefing



AOPA Weather Category	Yes	No	Unknown
Wind	32.0%	60.0%	8.0%
Low Visibility	66.0%	29.0%	5.0%
Fog	64.0%	32.0%	4.0%
Low Ceiling	67.0%	28.0%	6.0%
VFR into IMC	63.0%	33.0%	3.0%
Density Altitude	24.0%	71.0%	5.0%
Rain	70.0%	24.0%	6.0%
Snow	56.0%	36.0%	8.0%
Icing	53.0%	41.0%	6.0%
Thunderstorm	62.0%	32.0%	5.0%
Total	**44.0%**	**50.0%**	**6.0%**

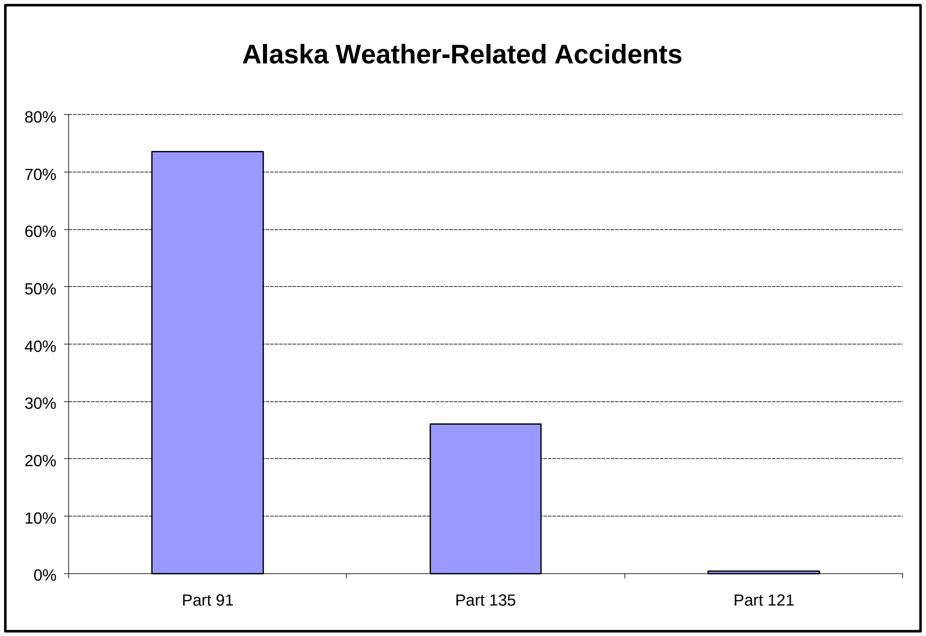
Weather-Related Accident Data Part 135 Commuter/Air Taxi Accidents

- 31% of all Part 135 Commuter/Air Taxi accidents between 1986 and 1995 are weather-related
- Visibility/Ceiling most frequent cause or factor cited in weather-related Commuter/Air Taxi accidents



Alaska Weather-Related Accidents Entire Region

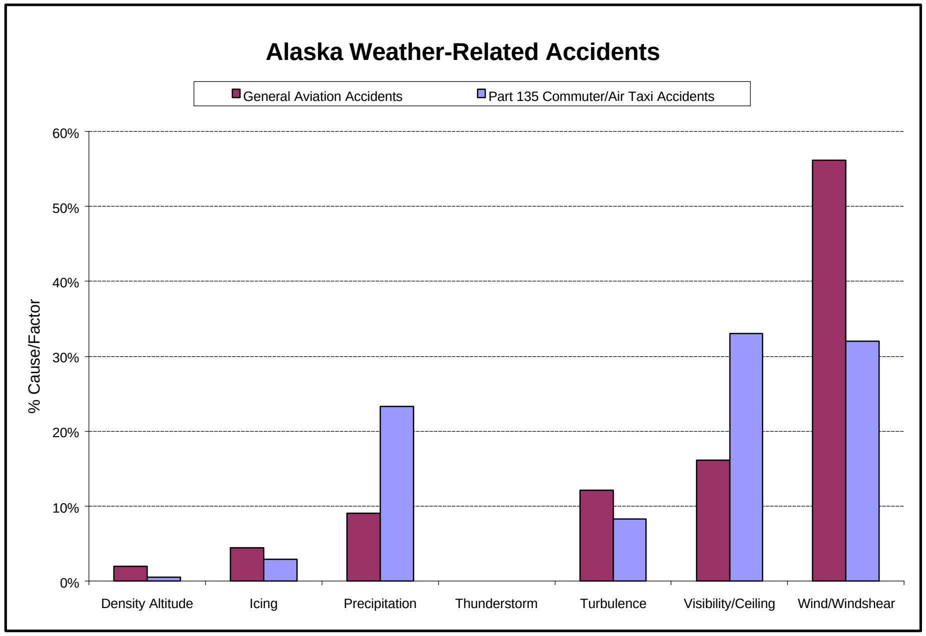
- Identified 1,712 Alaska NTSB accident reports between 1987 and 1996
  - 28% of the accidents are weather-related
  - While General Aviation account for 73% of the weather-related accidents, Part 135 Commuter/Air Taxi account for 26%, more than 4 times higher than the national average



Operations Type	Alaska Weather-Related Accidents
Part 91	353
Part 135	125
Part 121	2
Total	**480**

Alaska Weather-Related Accidents Entire Region (Cont'd)

- Percentages of weather factors show similar trends for Alaska accidents as for the national accidents
  - Wind/Windshear cited most often for General Aviation accidents
  - Visibility/Ceiling cited most often for Part 135 Commuter/Air Taxi accidents though Wind/Windshear also cited often
  - Air Carrier had one Turbulence and one Wind/Windshear citation

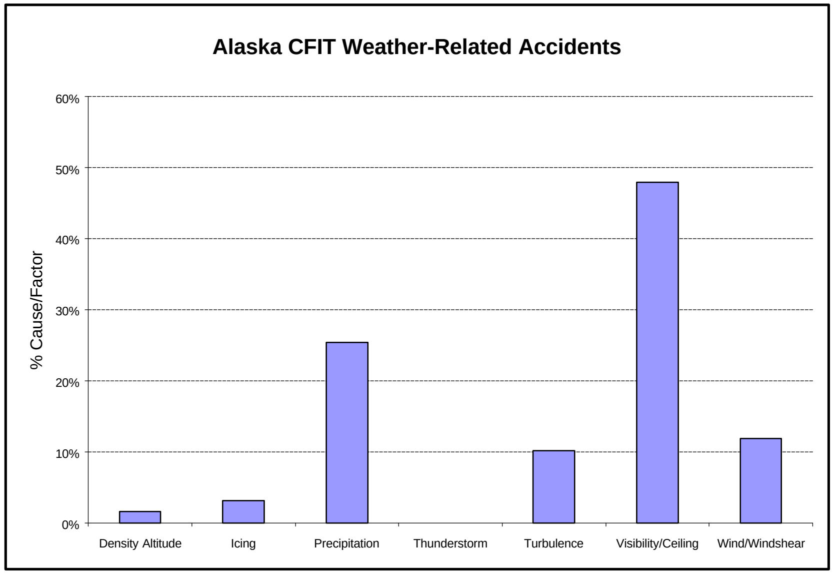


SF21

Preliminary Results

Alaska Weather-Related Accidents Entire Region (Cont'd)

- Majority of CFIT accidents in Alaska are weather-related
  - 347 CFIT accidents in Alaska between 1983 and 1997
    - 63% of the accidents are weather-related
    - 37% of the accidents are not weather-related
  - Visibility/Ceiling most frequent cause or factor cited in CFIT weather-related accidents



Alaska Weather-Related Accidents Bethel

- 21 accidents occurred in the Bethel, Alaska region between 1987 and 1996
  - 9 of the accidents (43%) are weather-related
    - 5 accidents involve Part 135 Commuter/Air Taxi
    - 4 accidents involve General Aviation
  - Wind/Windshear most common cause or factor cited

				Injury							
Date	**City**	**State**	**Phase of Flight**	**Fatal**	**Serious**	**Minor**	**None**	**Opr Category**	**CFIT**	**Weather Categories**	**Description of Event**
12/4/96	Bethel	AK	Takeoff	0	0	0	3	Part 135		Wind/Windshear	Aircraft took off with a tailwind and crashed 1/8 mile from departure end of runway
3/20/95	Bethel	AK	Maneuvering	0	0	0	2	Part 135	X	Precipitation	Aircraft encountered whiteout conditions 14 miles from Bethel Airport. Aircraft attempted return to airport but collided with terrain 5 miles from airport
11/12/94	Bethel	AK	Landing	0	0	0	3	Part 135		Wind/Windshear	Aircraft landed in a crosswind and ran off the edge of the runway
8/9/94	Bethel	AK	Landing	0	0	1	0	Part 135		Wind/Windshear	Pilot misundersttod the strenght of the tailwind and landed plane halway down the wet sand/gravel strip
9/9/92	Bethel	AK	Cruise	0	0	0	2	Part 91		Icing	Engine stall due to carburetor icing
9/4/91	Bethel	AK	Takeoff	0	0	0	1	Part 91		Wind/Windshear	Pilot lost control of the aircraft soon after takeoff due to unfavorable wind
9/30/90	Bethel	AK	Maneuvering	1	0	0	0	Part 91	X	Visibility/Ceiling	Continued VFR flight by the pilot into IMC resulted in impact with mountain
6/23/88	Bethel	AK	Takeoff	0	0	0	1	Part 91		Wind/Windshear	Aircraft attempted takeoff during crosswind and veered off runway
12/19/87	Bethel	AK	Takeoff	0	0	2	8	Part 135		Wind/Windshear	Aircraft took off with a tailwind and could not sustain flight
Total				**1**	**0**	**3**	**20**				

Summary

- Improving cockpit weather information is a high priority of the FAA and the General Aviation community
  - Research programs and demonstration projects are currently underway
  - Initial evaluations have shown improvement in situational awareness

- Need to analyze weather-related accidents by operations type and weather category
  - 23.5% of all accidents in the NTSB database between 1987 and 1996 were weather-related
  - Majority of weather-related accidents, fatalities and other injuries occur in General Aviation operations
  - Turbulence is the most common cause or factor in Air Carrier weather-related accidents and injuries but Icing is the most common cause or factor in Air Carrier weather-related fatalities
  - Wind/Windshear is the most common cause or factor in General Aviation weather-related accidents and injuries but Visibility/Ceiling is the most common cause or factor in General Aviation weather-related fatalities

Summary (Cont'd)

- Significant number of weather-related accidents in Alaska
  - 28% of Alaska accidents between 1987 and 1996 are weather-related
    - Majority of accidents involve General Aviation operations
    - Percentage of Part 135 Commuter/Air Taxi accidents more than 4 times higher than national average
  - 63% of Alaska CFIT accidents are weather-related

Enhancement 2: CFIT Results

Safe Flight 21

Enhancement 2 CFIT

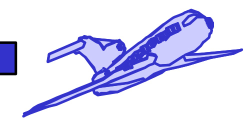
February 28, 2000

Controlled Flight Into Terrain Definition

- A CFIT accident is any collision with terrain (or water) in which the pilot was in control of the aircraft but was not aware of the airplane's altitude, the terrain elevation, or the airplane's position in terms of latitude or longitude
- Analysis of data shows that a majority of CFIT-related accidents for Alaska are weather related
  - 63% of the 347 CFIT accidents in AK between 1983 and 1997 can be attributed to weather.

- *For details on CFIT approach see MCR Federal document WN-9701/021-03 dated 27 January 2000*

CFIT Assumptions



CONUS less AK

YEAR	Equippage Rate	Air carrier w/out	Air Taxi	GA	total
2002	5%	(1988-1994)	(1988-1994)	(1983-1994)	
2003	10%	Note: The accident numbers below are only for Fatal			
2004	16%	Accidents with TAWs			
2005	21%	2	5	50.784	57.784
2006	27%	14	45	106	
2007	32%	Accidents without TAWS			
2008	38%	0	40	557.776	597.776
2009	43%		127	1162	
2010	49%	Total accidents			
2011	55%	2	45	608.56	655.56
	Effectiveness	**With TAWs Accidents per 100000 ops**			
	0.5	0.0023	0.0089	0.0084	
		Without TAWS Accidents per 100000 ops			
		-	0.0738	0.0847	
		Cost per Accident with TAWS (millions)			
		$ 38.38	$ 17.06	$ 4.00	
		Cost per Accident with NO TAWS (millions)			
		$ -	$ 6.31	$ 4.27	

Alaska

YEAR	Equippage Rate	Air carrier w/out	Air Taxi	GA	total
2002	13%	Accidents with TAWs 1983 to 1997			
2003	24%	1	7	0	8
2004	35%	Accidents without TAWS 1983 to 1997			
2005	45%	2	81	226	309
2006	56%	Total accidents 1983 to 1997			
2007	57%	3	88	226	317
2008	56%	**With TAWs Accidents per 100000 ops**			
2009	56%	0.0380	0.0648	-	
2010	56%	**Without TAWS Accidents per 100000 ops**			
2011	55%	0.076	0.750	1.319	
	Effectiveness	**Cost per Accident with TAWS (millions)**			
	0.75	$ 20.12	10.854	-	
		Cost per Accident with NO TAWS (millions)			
		$ 17.81	4.788	2.488	

- *Accident, injury / damage rates, and fleet mix are based on analysis of NTSB accidents*
- *TAWs will be required for all turbine powered aircraft with 6 or more passengers, and any 121 certified aircraft.*

Safety: 2 - CFIT

- It is assumed that SF21 and TAWS share the remaining unclaimed CFIT benefits pool.
  - TAWs will be required for all turbine powered aircraft with 6 or more passengers, and any 121 certified aircraft.
  - There is an overlap with weather accidents as well Those accidents are counted here and removed from weather.
- CFIT will have an assumed effectiveness rate of 75%
- Equipage for CFIT will be mainly for Part 91 and 135 aircraft.

Terrain Awareness Benefits (2002-2011)

	Constant $M	LD: AK	NAS
	Benefits Pool	$ 966	$ 4,628
Minus	Existing/Planned Capabilities (TAWS)	$ 94	$ 683
Equal	Remaining Pool	$ 873	$ 3,945
	Effectiveness (75%)	$ 654	$ 2,959
	Equipage Factor	$ 297	$ 886

* Benefits Pool Overlaps with FIS-B Ben Pool

* Benefits for NAS do not include AK
- they are additive

Enhancement 2: Controlled Flight Into Terrain Accident Data Review

WN-9701/021-03

Safe Flight 21 Program

Controlled Flight Into Terrain Accident Data Review

Version 2

27 January 2000

Outline

- Data Collection
- CFIT Definition
- Background
- Accident Data
- Alaska Results
- Effectiveness
- Summary

Data Collection

- Previous Studies
  - *An Analysis of Controlled-Flight-Into-Terrain (CFIT) Accidents of Commercial Operators 1988 through 1994*, Flight Safety Digest, Flight Safety Foundation; April-May 1996.
  - Volpe study: General Aviation CFIT Accidents 1983 through 1994
  - *Investigation of Controlled Flight Into Terrain:*
    - *Aircraft Accidents Involving Turbine-Powered Aircraft with Six or More Passenger Seats Flying Under FAR Part 91 Flight Rules and the Potential for Their Prevention by Ground Proximity Warning Systems (GPWS)*, U.S. Department Of Transportation, DOT-TSC-FA6D1-96-01; March 1996.
    - *For Selected Aircraft Accidents Involving Aircraft Flying Under Part 121 and 135 Flight Rules and the Potential for Their Prevention by Enhanced Ground Proximity Warning Systems (EGPWS)*, U.S. Department Of Transportation, DOT-TSC-FA6D1-96-03; July 1996.
    - *Descriptions of Flight Paths for Selected Controlled Flight into Terrain (CFIT) Aircraft Accidents, 1985-1997*, U.S. Department Of Transportation, DOT-TSC-FA9D1-99-01; March 1999.

Data Collection (Cont'd)

- National Transportation Safety Board (NTSB)
  - U.S. Commercial Operator CFIT Accidents 1988 through 1994
  - Publications with CFIT in the title
  - Relevant NTSB occurrence codes

CFIT Definition

- Flight Safety Foundation report
  - An otherwise serviceable aircraft, under the control of the crew, is flown (unintentionally) into terrain, obstacles or water, with no prior awareness on the part of the crew of the impending collision.

- Volpe study
  - Any collision with terrain (or water) in which the pilot was in control of the aircraft but was not aware of the airplane's altitude, the terrain elevation, or the airplane's position in terms of latitude and longitude.

- DOT reports
  - An airworthy aircraft, experiencing no contributory systems or equipment problems, under the control of a certificated, fully qualified flight crew not suffering from any impairment, is flown into terrain (or water or obstacle) with no demonstrated prior awareness of the impending collision on the part of the crew. Or, if the flight crew was aware of the impending collision, they were unable to prevent it.

Background

- Introduction of the Ground Proximity Warning System (GPWS) into the U.S. Air Carrier fleet in response to the 1974 TWA crash at Washington Dulles
  - Used altimeter and barometric data as inputs
  - Generated visual and audible alerts typically 30 seconds or less before impact
  - Provided warnings under five potentially hazardous flight conditions
    - Excessive rate of descent
    - Excessive rate of closure with terrain
    - Negative climb rate or altitude loss after takeoff or missed approach
    - Insufficient terrain clearance when landing gear or flaps are not set in landing configuration
    - Excessive downward deviation from an instrument landing system (ILS) glide slope signal or precision approach
  - Led to a reduction of air carrier CFIT accidents but still had some limitations

Background (Cont'd)

- Significant enhancements to GPWS technology over the past several years
  - Rely on lightweight, low-cost, and powerful computer storage devices and Global Positioning System (GPS) signal receivers
    - Storage of detailed terrain data in the cockpit
    - Determination of precise aircraft location
  - Developments address GPWS two major limitations
    - "Forward-looking" terrain display based on a comparison of aircraft location coordinates with stored terrain data
    - Terrain clearance "floor" which will provide alerts on non-precision approaches independent of landing gear or flap settings
  - Features can be presented on a cockpit "moving map" display

Background (Cont'd)

- Terrain Awareness and Warning System (TAWS) adds enhancements to traditional GPWS systems
  - Includes three capabilities
    - Terrain display
    - Terrain awareness and alerting functions that use aircraft position information and an on-board terrain database
    - Ground proximity detection and alerting (traditional GPWS functions)
  - Significant improvements over traditional GPWS systems
    - Continuous terrain display will increase flight crew situational awareness in limited visibility
    - Warnings generated for non-precision approach situations
    - Warning times now measured in minutes rather than seconds
  - Upcoming regulation requiring TAWS on all turbine-powered airplanes with six or more seats operating under Part 91 and Part 135; and all turbine powered airplanes operating under Part 121

Accident Data Commercial Operators

- Flight Safety Foundation report
  - Based on a study by the Netherlands National Aerospace Laboratory (NLR)
  - Identifies 156 CFIT accidents from 1988 through 1994
    - Includes U.S. and international data
    - Includes fatal accidents only (most CFIT accidents result in fatalities)
    - Excludes collisions with terrain or water caused by problems such as:

      Hard landings; Unstabilized approaches; Gear-up landings or failures of landing gear; Runway overruns; Emergency descents; Fuel exhaustion; Downdraft/windshear/wake vortex; Icing on airframe or wings; Bird strikes; Loss of power; Control-system problems; Pilot incapacitation; Sabotage/hijacking; Military action; Intoxication or drug use
  - Lists 51accidents within the U.S.
    - MCR located 49 of the NTSB accident reports
    - 2 events not found in the NTSB database (2/10/88 & 5/18/88)

Accident Data Commercial Operators (Cont'd)

- 49 U.S. events located in NTSB database
  - Over 90% involve Part 135 operations

	Part 129		Part 135			
Type	**SCH**	**NSC**	**SCH**	**NSC**	**Part 91**	**Total**
Air Carrier	1					1
Commuter			10	5	1	16
Air Taxi		1		30	1	32
Total	1	1	10	35	2	49

  - Over 80% are not included in the upcoming TAWS regulation
    - 37 piston engine aircraft operating under Part 135
    - 3 turbine engine aircraft with less than 6 seats operating under Part 135

	Part 129		Part 135				TAWS Regulation	
Type	**SCH**	**NSC**	**SCH**	**NSC**	**Part 91**	**Total**	**Yes**	**No**
Turbine								
6 or more seats		1	4	1	2	8	8	0
Less than 6 seats	1			3		4	1	3
Piston			6	31		37	0	37
Total	1	1	10	35	2	49	9	40

* One-third (12 of 37) of the Part 135 piston engine aircraft accidents occurred in Alaska

Accident Data Commercial Operators (Cont'd)

- 189 fatalities with the remaining 18 survivors experiencing serious injury
  - Fatalities

Type	Part 129 SCH	Part 129 NSC	Part 135 SCH	Part 135 NSC	Part 91	Total
Turbine						
6 or more seats		12	44	1	3	60
Less than 6 seats	2			5		7
Piston			19	103		122
Total	2	12	63	109	3	189

TAWS Regulation Yes	TAWS Regulation No
60	0
2	5
0	122
62	127

  - Serious injuries

Type	Part 129 SCH	Part 129 NSC	Part 135 SCH	Part 135 NSC	Part 91	Total
Turbine						
6 or more seats				3		3
Less than 6 seats						0
Piston			3	12		15
Total	0	0	3	15	0	18

TAWS Regulation Yes	TAWS Regulation No
3	0
0	0
0	15
3	15

- 45 aircraft destroyed with 4 non-scheduled Part 135 aircraft substantially damaged (3 piston; 1 turbine with less than 6 seats)

Accident Data Commercial Operators (Cont'd)

- Majority occur during approach or cruise phase of flight

Phase of Flight	Total
Takeoff	1
Climb	5
Climb - To Cruise	1
Cruise (includes low altitude straight and level flight)	12
Maneuvering (includes buzzing)	7
Descent	2
Descent - Normal	1
Approach	5
Approach - Circling (IFR)	2
Approach - FAF/Outer Marker To Threshold (IFR)	8
Approach - IAF To FAF/Outer Marker (IFR)	3
Missed Approach (IFR)	2
Total	49

- Majority occur during poor visibility conditions

	Basic Weather Conditions			
Visibility Restrictions	IMC	VMC	Unknown	Total
Fog	25	2	0	27
Blowing Snow	6	0	1	7
Haze	0	1	0	1
Ice Fog	1	0	0	1
Unknown	4	0	1	5
None	3	5	0	8
Total	39	8	2	49

Accident Data Commercial Operators (Cont'd)

- Volpe study
  - Focuses on general aviation accidents
  - Appendix includes non-GA accident data from 1983 through 1994
  - Reflects 37% increase in fatal accidents per year and 14% increase in fatalities per year when compared to Flight Safety Foundation report

Item	**Volpe**	**Flight Safety Foundation**
Period	1983 to 1994	1988 to 1994
Accidents per Year	14.2	---
Fatal Accidents per Year	9.6	7.0
Fatalities per Year	30.8	27.0

Accident Data Commercial Operators (Cont'd)

- Summary
  - Significant costs associated with fatal accidents involving aircraft not included in upcoming TAWS regulation based on Flight Safety Foundation report
    - $400 million total costs between 1988 and 1994
    - $57 million average annual costs

Item	Number	Unit Cost ($K)	Total Cost ($K)
Personal Injury			
Fatalities	127	$2,700	$342,900
Serious Injury	15	$522	$7,827
Aircraft Damage			
Commuter			
Destroyed	8	$3,740	$29,920
Substantial	2	$501	$1,002
Air Taxi			
Destroyed	28	$665	$18,620
Substantial	2	$143	$286
Total			$400,555
Average Per Year			$57,222

  - Excludes non-fatal accidents
  - Statistics from the Volpe study indicate that costs may be even greater

Accident Data General Aviation

- Volpe study
  - Identifies 1,260 CFIT accidents from 1983 through 1994
    - Includes general aviation aircraft and helicopters
    - Excludes other aircraft such as ultralights and blimps
  - CFIT accidents are more likely to result in fatalities than other accidents

Item	**CFIT**	**Other**
Fatal Accidents per Year	71.5	371.0
Accidents per Year	105.0	2106.1
% Fatal Accidents	68%	18%
Fatalities per Year	149.1	704.3
Fatalities per Accident	1.42	0.33

  - Over 50% of CFIT accidents occur in IMC versus less than 6% for all other accidents combined
    - Accounts for over 30% of all accidents in IMC
    - Accounts for 35% of VFR rated pilots in IMC

Accident Data General Aviation (Cont'd)

- Estimate number of general aviation accidents involving aircraft not included in upcoming TAWS regulation
  - Initial estimate based on percentage of piston aircraft in population
  - Over 90% of general aviation aircraft are piston engine per FAA General Aviation and Air Taxi Survey (May 1999)

Type	GA Aircraft	% Total
Piston	156,056	93.5%
Turboprop	5,619	3.4%
Turbojet	5,178	3.1%
Total	166,853	100.0%

  - Apply general aviation population percentages to CFIT data (covered by TAWS regulation)

Item	All General Aviation	Involving Piston Aircraft
Accidents per Year	105.0	98.2
Fatal Accidents per Year	71.5	66.9
Fatalities per Year	149.1	139.4

Accident Data General Aviation (Cont'd)

- Summary
  - $415 million average annual costs associated with accidents involving aircraft not included in upcoming TAWS regulation based on Volpe study

Item	Annual Number	Unit Cost ($K)	Total Cost ($K)
Personal Injury			
Fatalities	139.4	$2,700	$376,478
Other Injury	---	---	---
Aircraft Damage			
Destroyed	66.9	$522	$34,908
Substantial	31.3	$133	$4,167
Total			$415,553

  - Excludes serious and minor injuries
  - Assumes all fatal accidents result in destroyed aircraft and the non-fatal accidents result in substantial damage

Accident Data Additional Data

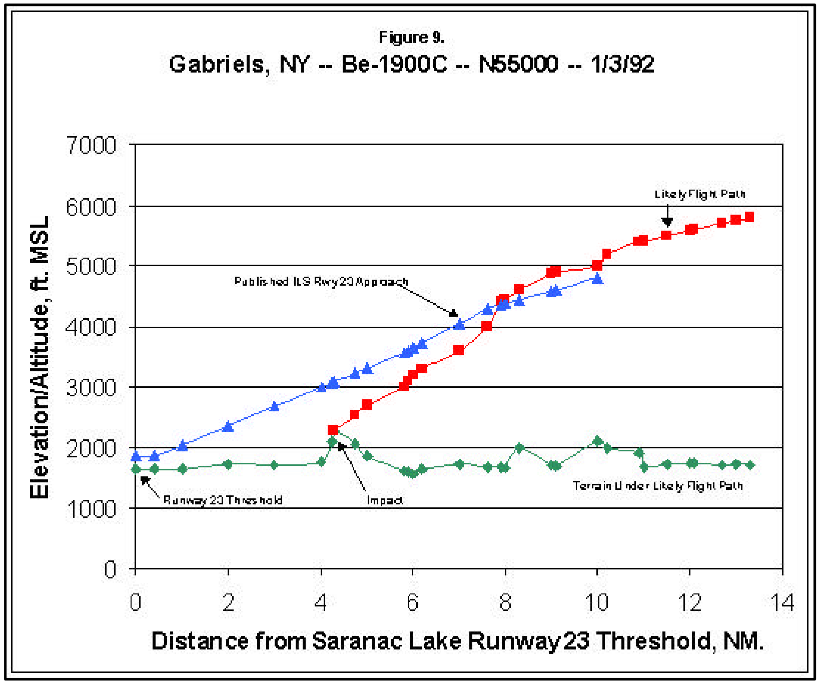
- Identified 10 NTSB publications with CFIT in the title
  - More complete description of accident available
  - May be useful for case study analysis

Date	City	State	Aircraft	Type	Basic Wx
08/06/97	Nimitz Hill	Guam	B-747	SCH 129	IMC
04/11/96	Cheyenne	WY	CE-177	Gen Avn	IMC
11/12/95	East Granby	CT	MD-83	SCH 121	IMC
07/02/94	Charlotte	NC	DC-9	SCH 121	IMC
06/18/94	Chantilly	VA	Lear 25D	NSC 129	IMC
12/01/93	Hibbing	MN	BA-3100	SCH 135	IMC
10/26/93	Front Royal	VA	BE-300	Gen Avn	IMC
06/08/92	Anniston	AL	BE-C99	SCH 135	VMC
04/22/92	Maui	HI	BE-18S	NSC 125	IMC
06/02/90	Unalakleet	AK	B-737	SCH 121	IMC

Accident Data Additional Data (Cont'd)

- Department of Transportation report
  - Researched 13 select CFIT accidents
  - Analyzed flight path data

Date	Location	Aircraft	Fatalities
08/06/97	Nimitz Hill, Guam	B-747-300	225
12/20/95	Buga, Colombia	B-757-200	160
11/13/92	East Granby, CT	MD-83	0
06/24/92	Alamogordo, NM	MU-2B-30	6
01/03/92	Gabriels, NY	Be-1900C	2
12/11/91	Rome, GA	Be-400	9
03/16/91	San Diego, CA	HS-125	10
10/28/89	Halawa Point, HI	DHC-6-300	20
10/21/89	Tegucigalpa, Honduras	B-727-200	131
03/27/87	Eagle, CO	LJ-24A	3
12/10/86	Windsor, MA	Be-100	6
08/23/85	Flat Rock, NC	PA-31T	5
01/01/85	La Paz, Bolivia	B-727-225	29



SF21

Preliminary Results

Alaska Results Methodology

- Identified NTSB occurrence codes related to CFIT accidents
  - All commercial operator accidents from 1998 to 1994 cited code 220 or code 230
    - Code 220: In Flight Collision With Object
    - Code 230: In Flight Collision With Terrain/Water

Source	Occurrence Code 220	Occurrence Code 230	Total
Flight Safety Foundation report	5	44	49

  - Reviewed all accident reports in Alaska between 1983 and 1997 that cited either code 220 or code 230 to determine which qualify as CFIT events

Flight Code	CFIT Yes	CFIT No	Total
Part 121/129	3	5	8
Part 135	97	136	233
Part 91	239	612	851
Other	8	18	26
Total	347	771	1,118

Alaska Results Overview

- Only 8 of 347 CFIT accidents in Alaska between 1983 and 1997 involve aircraft to be included in the upcoming TAWS regulation
  - Predominately involve piston aircraft
  - Almost 10% involve helicopters

						TAWS Regulation	
Type	**Part 121/129**	**Part 135**	**Part 91**	**Other**	**Total**	**Yes**	**No**
Aircraft							
Turbine w/ 6 or more seats	1	7	0	0	8	8	0
Turbine w/ less than 6 seats	0	2	1	0	3	0	3
Piston	2	79	222	3	306	0	306
Helicopter	0	9	16	5	30	0	30
Total	3	97	239	8	347	8	339

Alaska Results Overview (Cont'd)

- 343 total fatalities accounting for 40% of the people involved

Fatalities

Type	Part 121/129	Part 135	Part 91	Other	Total	TAWS Regulation Yes	TAWS Regulation No
Aircraft							
Turbine w/ 6 or more seats	0	26	0	0	26	26	0
Turbine w/ less than 6 seats	0	6	1	0	7	0	7
Piston	5	116	169	2	292	0	292
Helicopter	0	2	10	6	18	0	18
Total	5	150	180	8	343	26	317

Serious Injury

Type	Part 121/129	Part 135	Part 91	Other	Total	TAWS Regulation Yes	TAWS Regulation No
Aircraft							
Turbine w/ 6 or more seats	1	5	0	0	6	6	0
Turbine w/ less than 6 seats	0	0	0	0	0	0	0
Piston	0	46	65	0	111	0	111
Helicopter	0	3	4	8	15	0	15
Total	1	54	69	8	132	6	126

Minor Injury

Type	Part 121/129	Part 135	Part 91	Other	Total	TAWS Regulation Yes	TAWS Regulation No
Aircraft							
Turbine w/ 6 or more seats	3	2	0	0	5	5	0
Turbine w/ less than 6 seats	0	0	0	0	0	0	0
Piston	0	28	70	1	99	0	99
Helicopter	0	6	7	2	15	0	15
Total	3	36	77	3	119	5	114

No Injuries

Type	Part 121/129	Part 135	Part 91	Other	Total	TAWS Regulation Yes	TAWS Regulation No
Aircraft							
Turbine w/ 6 or more seats	0	20	0	0	20	20	0
Turbine w/ less than 6 seats	0	0	0	0	0	0	0
Piston	3	56	140	1	200	0	200
Helicopter	0	17	19	2	38	0	38
Total	3	93	159	3	258	20	238

Alaska Results Overview (Cont'd)

- 139 destroyed aircraft accounting for 40% of the accidents
- All but 3 of the remaining aircraft substantially damaged

Destroyed

Type	Part 121/129	Part 135	Part 91	Other	Total	TAWS Regulation Yes	TAWS Regulation No
Aircraft							
Turbine w/ 6 or more seats	1	4	0	0	5	5	0
Turbine w/ less than 6 seats	0	2	1	0	3	0	3
Piston	1	40	79	1	121	0	121
Helicopter	0	4	5	1	10	0	10
Total	2	50	85	2	139	5	134

Substantial

Type	Part 121/129	Part 135	Part 91	Other	Total	TAWS Regulation Yes	TAWS Regulation No
Aircraft							
Turbine w/ 6 or more seats	0	3	0	0	3	3	0
Turbine w/ less than 6 seats	0	0	0	0	0	0	0
Piston	1	38	142	1	182	0	182
Helicopter	0	5	11	4	20	0	20
Total	1	46	153	5	205	3	202

Minor

Type	Part 121/129	Part 135	Part 91	Other	Total	TAWS Regulation Yes	TAWS Regulation No
Aircraft							
Turbine w/ 6 or more seats	0	0	0	0	0	0	0
Turbine w/ less than 6 seats	0	0	0	0	0	0	0
Piston	0	1	1	1	3	0	3
Helicopter	0	0	0	0	0	0	0
Total	0	1	1	1	3	0	3

Alaska Results Overview (Cont’d)

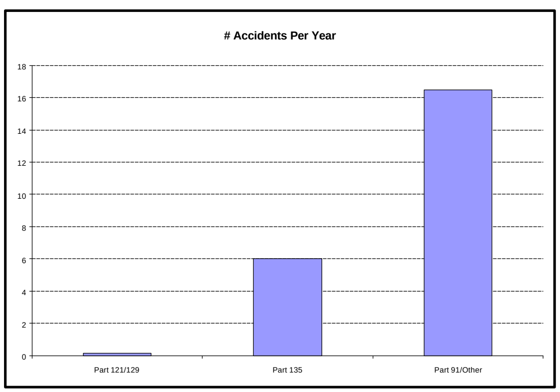
- Annually over 22 accidents and $70 million in injuries and aircraft damages involving aircraft not included in upcoming TAWS regulation

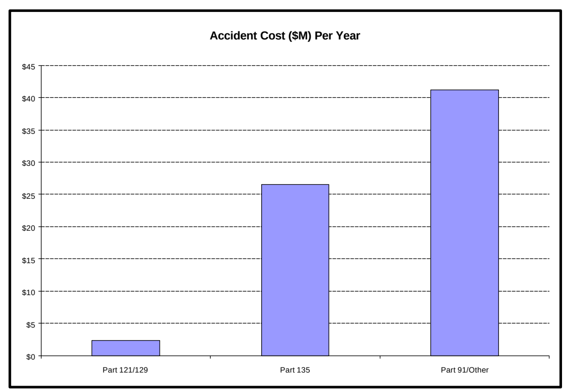
Part 121/129		Unit	Total
Item	**Number**	**Cost ($K)**	**Cost ($K)**
Personal Injury			
Fatalities	5	$2,700	$13,500
Serious Injury	0	$522	$0
Minor Injury	0	$39	$0
Aircraft Damage			
Destroyed	1	$19,480	$19,480
Substantial	1	$2,630	$2,630
Total			$35,610
# Accidents			2
Cost Per Accident			$17,805
# Accidents Per Year			0.13
Cost Per Year			$2,374

Part 135		Unit	Total
Item	**Number**	**Cost ($K)**	**Cost ($K)**
Personal Injury			
Fatalities	124	$2,700	$334,800
Serious Injury	49	$522	$25,568
Minor Injury	34	$39	$1,309
Aircraft Damage			
Destroyed	46	$665	$30,590
Substantial	43	$143	$6,149
Total			$398,416
# Accidents			90
Cost Per Accident			$4,427
# Accidents Per Year			6.00
Cost Per Year			$26,561

Part 91 / Other		Unit	Total
Item	**Number**	**Cost ($K)**	**Cost ($K)**
Personal Injury			
Fatalities	188	$2,700	$507,600
Serious Injury	77	$522	$40,179
Minor Injury	80	$39	$3,080
Aircraft Damage			
Destroyed	87	$522	$45,414
Substantial	158	$133	$21,014
Total			$617,287
# Accidents			247
Cost Per Accident			$2,499
# Accidents Per Year			16.47
Cost Per Year			$41,152

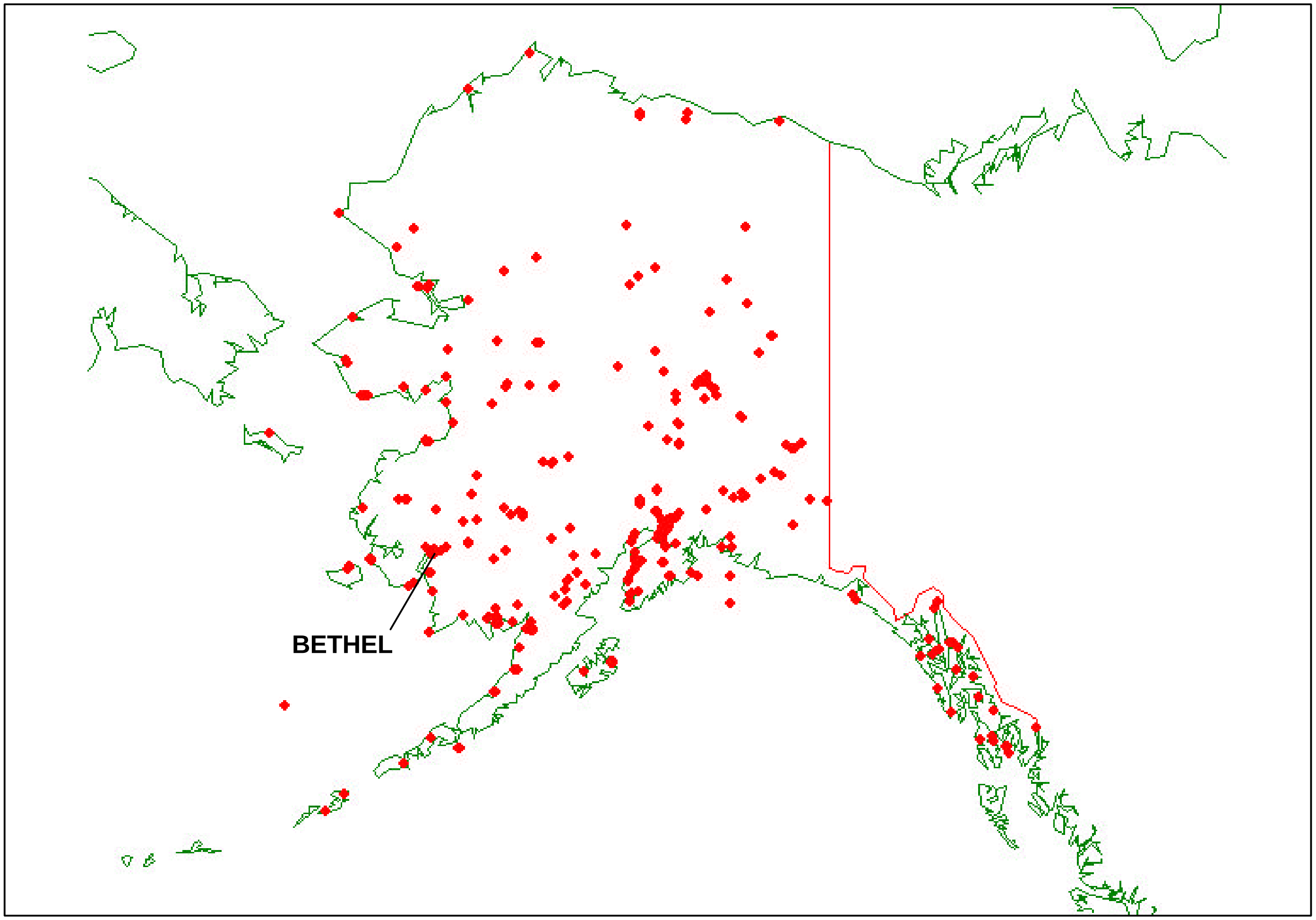
Total	
Item	**Total**
Personal Injury	
Fatalities	$855,900
Serious Injury	$65,747
Minor Injury	$4,389
Aircraft Damage	
Destroyed	$95,484
Substantial	$29,793
Total	$1,051,313
# Accidents	339
Cost Per Accident	$3,101
# Accidents Per Year	22.60
Cost Per Year	$70,088





Alaska Results
Bethel, AK

LOCATION OF CFIT ACCIDENTS



SF21

Preliminary Results

Alaska Results
Bethel, AK (Cont'd)

- 5 CFIT accidents in Bethel, AK between 1983 and 1997
  - All involved aircraft not included in upcoming TAWS regulation
  - 3 Part 135 accidents
    - 2 fatalities
    - 2 aircraft destroyed and 1 substantially damaged
  - 2 Part 91 accidents
    - 1 fatality
    - 1 aircraft destroyed and 1 substantially damaged

Report Number	Date	Operations Type	Aircraft Make	Aircraft Model	Engine Type	# Seats	Aircraft Damage	Fatalities	Serious	Minor	None
ANC97FA008	11/26/96	Part 135	CESSNA	CE-208B	Turbo Prop	2	Destroyed	1	0	0	0
ANC95LA036	03/20/95	Part 135	CESSNA	CE-207	Piston	8	Substantial	0	0	0	2
ANC90LA189	09/30/90	Part 91	MAULE	M-4	Piston	4	Destroyed	1	0	0	0
ANC90FA039	03/16/90	Part 135	PIPER	PA-32-301	Piston	6	Destroyed	1	0	0	0
ANC90LA002	10/01/89	Part 91	PIPER	PA-32	Piston	6	Substantial	0	0	0	1

Effectiveness
Part 91

- 44 CFIT accidents examined from 1985 to 1994
  - Accident criteria
    - Part 91operation
    - Turbine powered aircraft with six or more passenger seats
  - Characterization of last several minutes of flight
    - Would current GPWS technology sound a warning
    - When would the earliest GPWS warning have sounded

- Geometric model based on aircraft airspeed along its flight path, flight path angle, ground slope angle, and aircraft altitude at earliest warning point
  - Calculate distance and time to impact from earliest warning point
  - Compare time to impact with minimum effective response time of 12-15 seconds

- Additional consideration given to GPS-enhanced GPWS capabilities

Effectiveness
Part 91 (Cont'd)

- Minimum effective response time is based on pilot and aircraft response times
  - Pilot response time is on the order of 5 to 7 seconds
    - Assumes instantaneous action without questioning system reliability
    - Based on TCAS study of pilot responses
  - Aircraft response time will range from 5 seconds for turboprops and turbojets in takeoff or cruise flight to 10 seconds for turbojets on approach
    - Maximum thrust is reached in 3 to 4 seconds for turboprops and turbojets operating at high revolutions per minute (takeoff and cruise)
    - Maximum thrust can take as long as 8 seconds for a turbojet operating at low revolutions per minute (approach)
    - Average response is to raise the aircraft into an 8-1/2 degree nose-up climb which takes 1 second once maximum thrust is achieved

Effectiveness
Part 91 (Cont'd)

- 44 CFIT accidents involved 11 turbojets and 33 turboprops
  - Accident categorization
    - 23 involved low approach / premature descent
    - 11 involved collision with rising terrain
    - 5 involved descent after takeoff or missed approach
    - 5 involved gear-up landings
  - Injuries and aircraft damage
    - 131 fatalities, 19 serious injuries, and 26 minor or no injuries
    - 37 destroyed aircraft
  - Pilot error was a probable cause in all cases
    - Failure to maintain proper altitude
    - Using improper IFR or VFR procedures
    - Poor planning / decision making

Effectiveness
Part 91 (Cont'd)

- Current GPWS technology is determined to be 75% effective in preventing accidents
  - Would have sounded a warning in 38 of 44 accidents
  - 33 of the 38 warnings would have been in time to prevent accident
  - Not effective for 11 of the 44 accidents
    - 8 were categorized as low approach / premature descent
    - 3 were categorized as collision with rising terrain

- EGPWS is determined to be 95% effective in preventing accidents
  - Would have prevented 9 of the 11 accidents not prevented by GPWS
  - Not effective for 2 accidents that were low approach / premature descent where the aircraft impacted within 1 nm from the landing runway in a steep descent

Effectiveness
Part 121 & Part 135

- CFIT accidents partitioned into four groups to determine EGPWS effectiveness
  - No GPWS on board
  - GPWS on board but no warning
  - GPWS on board and warning, but insufficient reaction time
  - GPWS on board and warning with sufficient reaction time

- Examined 9 international accidents across all categories
  - Determine earliest GPWS warning times
    - Base on geometric model for accidents where actual warning was not present
    - Base on cockpit voice recorder analysis of actual warning times
  - Compare manufacturer provided EGPWS warning times with GPWS performance

Effectiveness
Part 121 & Part 135 (Cont'd)

- 4 of the 9 accidents should have been prevented by current GPWS technology
  - 2 accidents where warning was not provided because equipment was disconnected or malfunctioned
  - 2 accidents where poor flight crew coordination led to inaction following warning
  - Warning times insufficient or not provided for remaining 5 accidents

- EGPWS is determined to be 100% effective in preventing accidents
  - Warning times were greater than the assumed 12-15 second minimum for all cases
  - Generally provides over 20 seconds additional lead time over GPWS
  - Forward looking terrain display also enhances effectiveness

Summary

- Most CFIT accidents involve aircraft not included in upcoming TAWS regulation

Annual CFIT Accidents Not Included In Upcoming TAWS Regulation

Type	Timeframe	# Annual Accidents	Fatalities	Injuries	Aircraft Damage	Total Annual Cost ($K)
Alaska						
Bethel	83-97	0.33	$540	$0	$142	$682
Other	83-97	22.27	$56,520	$4,676	$8,210	$69,406
Nas-Wide						
Commercial	88-94	5.71	$48,986	$1,118	$7,118	$57,222
General Aviation	83-94	98.21	$376,478	---	$39,075	$415,553

* Nas-Wide Commercial includes fatal accidents only
* Nas-Wide General Aviation omits non-fatal injury data

- Effectiveness
  - Existing GPWS estimated to be 75% effective in preventing CFIT accidents
  - Enhanced GPWS estimated to be 95% to 100% effective in preventing accidents

Enhancement 3: Terminal Operations
Enhancement 7: Surface surveillance for the Controller

Enhancement 3 Terminal Operations & Enhancement 7 - Surface Surveillance for the Controller

Nastaran Coleman
Bryan Baszczewski
ASD-430

Outline

- Background/Objective
- Preliminary Analysis of UPS at SDF
- Enhanced Visual Approach Benefits for Limited Deployment
- Estimating Hourly Capacity
- Data Sources and References
- Estimating Delay using Queuing Theory
- Summary of Methodology
- Phase 2 Analysis Objectives

Background/Objective

- Enhancement 3 - Terminal Operations and Enhancement 7 - Surface Surveillance to the Controller inter-dependency:
  - Enhanced visual approach
  - Reduction of final approach spacing
  - Impact on departure spacing
  - Increased efficiency in the terminal and surface operations, which lead to increased airport capacity
- Objective: Estimate the benefits of increased airport capacity due to ADS-B equipage

Preliminary Analysis of UPS at SDF Assumptions Summary

- Maximize arrival rates at UPS hub airport by reducing Miles-In-Trail (MIT) restrictions.
- 50% ADS-B equipage rate over 2 years for entire UPS fleet (229 aircraft).
- Increased revenue from additional loading time at satellite cities.
- Increased sort time at hub airport.
- Current aircraft flight times: UPS Schedule, ETMS data.

Enhanced Visual Approach Benefits for Limited Deployment

- Mapped Weather conditions using 1998 NCDC data to three airports in the Ohio River Valley (ORV) ILN, SDF, and MEM arrivals using 1998 CODAS (ETMS) AZ-messages.
- Cargo operations for Airborne Express (ILN), Federal Express (MEM), and UPS (SDF) and NWA at MEM are considered
- ADS-B equipped aircraft
  - Operational performance during MVRF weather will be equivalent to that of VFR weather (Enhancement 3.1) for cargo/NWA flights with air delay > 0 during 24 hour period.
  - Improved inter-arrival rates will impact the departure queue by increasing total airport capacity
    - Improved arrival rates reduces delays due to waiting in queue (where it exists)
    - Improved taxi-out delays Weather conditions identified as VFR/MVFR/IFR.

Estimating Hourly Capacity (Acceptance Rate)

- Hourly capacity was estimated for three different scenarios for 65 airports.
  - Baseline: Current wake vortex separations + 24-27 seconds of buffer (varying by aircraft type combination.)
  - ADS-B equipped: Current wake vortex separations + 17-19 seconds buffer. A 30% reduction compared to baseline.
  - Upper bound: Current wake vortex separations + 0 seconds of buffer.
- Assumed that the buffers are normally distributed
- Hourly capacity mean and variance was calculated using EPS methodology and UPS report.
  - Hourly arrival and departure rates used to estimate the probabilities of A/A, A/D, D/D and D/A
  - Percent of each equipment class by airport (PMAC): Used to calculate probability of a heavy aircraft trailing a smaller one, ...

Data Sources for Capacity and Acceptance Rates (Cont'd)

- Threshold Separation Buffer from "CTAS Error Sensitivity, Fuel Efficiency and Throughput Benefit Analysis, 1996."
- Final approach and departure spacing minima for all class combinations using wake vortex standard in seconds. (Reference: Aeronautical Information Manual (AIM); Air Traffic Control handbook 7110.65L)
- Current and future capacity for 80 airports, IFR and VFR conditions (ASD-430).
- Weather conditions: Forty years NCDC averages: %VFR for visibility >= 5000 and ceiling >= 5.
- The complete set of input variables was only available for 65 airports

Estimating Delay

- Approximate delay reduction using queueing theory.
  - G/G/1 queue with FIFO discipline is assumed.
  - Similar assumptions are made in most-NAS wide simulation models such as NASPAC or DPAT.
- Lincoln Lab queueing model methodology is used when demand exceeds capacity
  - This methodology is also used in the outage model and GDP (ground delay programs).
- Actual average hourly flight delay by airport from ASQP is used when estimating delay savings.
- For both NAS and LD estimates, constraints around the maximum number of minutes of delay savings were placed in the model.

Approximations Using Queuing Theory in Equilibrium: Model 1

- In any *G*/*G*/1 queue, an upper bound on average delay is calculated using following formula:

$$Delay \le \frac{\lambda\left(\sigma_A^2 + \sigma_B^2\right)}{2\left(1 - \lambda/\mu\right)} \qquad \textbf{(1)}$$

λ=arrival/departure rate
μ=airport acceptance rate
σ_A^2=variance of inter-arrival time
σ_B^2=variance of service time

Summary of Methodology

- Three scenarios considered:
  - Scenario 1.- (Baseline) The threshold separation buffer is 24-27 seconds.
  - Scenario 2.- Assumed a 30% reduction over the baseline buffer due to ADS-B
  - Scenario 3.- Assumed ADS-B would reduce the buffer to 0, as used in UPS study - the absolute upper bound.
- Adjusted capacities to properly include the likelihood of different weather conditions.
- Assumed constraints around the maximum number of minutes of delay savings
  - A maximum of 5 minutes to Scenario 2
  - A maximum of 8 minutes to Scenario 3

Phase 2 Analysis Objectives

- Review/Validate the spreadsheet model including inputs
- Develop a methodology for air carriers to estimate the benefits of increased capacity in terms of additional flights.
- Enhance input files by estimating the fleet mix by hour using ETMS or CODAS data to include GA traffic instead of average daily traffic mix
- Do sensitivity analysis by changing inter-arrival/departure and service time variances.
- Reduce the 3 nautical miles wake vortex separations to 2.5 nm for visual approaches.
- The impact of equipage rates will be captured by airport as and input to the model rather than as a final step
- Link to Analytica

Enhancement 4: Enhanced See and Avoid

Enhancement 4:
Enhanced See and Avoid

Safety: 4 - Enhanced See and Avoid

- Accident rates for the state of Alaska were derived from accident data for the period between 1990 to 1998.
- Most Mid-Air Collisions are Part 91, in local area with no flight plan.
- 11 midair collisions occurred in Alaska during that 8-year timeframe (aircraft-to-aircraft collisions)
- Based on forecast number of operations in Alaska during the analysis period, 18 mid-air accidents are expected to happen - resulting in 30 fatalities.
- System effectiveness is assumed to be:
  - 75% with CDTI & Conflict Detection
  - 100% with CD and Resolution
- Figures are based on NASDAC data and APO values

Safety: 4 - Enhanced See and Avoid

- 80% of midair collisions involve aircraft operating under Part 91 operations (GA)
- Equipage rates are adjusted to account for the fact that avoided accidents can be attributed not only to ADS-B-equipped aircraft, but also to their ability to see other transponder- equipped aircraft
- A 75% effectiveness is based on CDTI only. CD&R increases effectiveness to 100% by FY05

Collision Avoidance Benefits (2002-2011)

	Constant $M	LD: AK	NAS
	Benefits Pool	$ 91	$ 863
Minus	Existing/Planned Capabilities	$ -	$ 16
Equal	Remaining Pool	$ 91	$ 846
	Effectiveness	$ 85	$ 790
	Equipage Factor	$ 48	$ 346

Midair Collisions - CONUS

(ADS-B with incremental 10% for TIS-B Scenario)
Full Funding (In Constant $M)

Year	Equipage rate	Existing TIS-B %	Total AC Damage	Total Cost of Injuries	Benefits Baseline	Reamining Pool	Effectiveness Factor	Effectiveness	Equipage
2002	13%	13%	$0.98	$7.16	$8.14	$8.14	75%	$6.11	$0.81
2003	24%	24%	$1.01	$7.34	$8.35	$8.35	75%	$6.27	$1.51
2004	35%	45%	$1.04	$7.53	$8.57	$8.57	75%	$6.43	$2.88
2005	45%	55%	$1.06	$7.73	$8.79	$8.79	100%	$8.79	$4.86
2006	56%	66%	$1.09	$7.93	$9.02	$9.02	100%	$9.02	$5.92
2007	57%	67%	$1.12	$8.13	$9.24	$9.24	100%	$9.24	$6.17
2008	56%	66%	$1.15	$8.33	$9.48	$9.48	100%	$9.48	$6.29
2009	56%	66%	$1.17	$8.54	$9.72	$9.72	100%	$9.72	$6.41
2010	56%	66%	$1.20	$8.76	$9.96	$9.96	100%	$9.96	$6.53
2011	55%	65%	$1.23	$8.97	$10.21	$10.21	100%	$10.21	$6.65
Total			**$11.06**	**$80.42**	**$91.48**	**$91.48**		**$85.21**	**$48.02**

Midair Collisions - CONUS

(ADS-B with incremental 10% for TIS-B Scenario)
Full Funding (In Constant $M)

Year	NAS -Wide Equipage Rate	Existing TCAS %	Total AC Damage	Total Cost of Injuries	Benefits Baseline	Existing /Planned Capabilities	Remaining Pool	Effectiveness	Equipage
2002	3%	3%	$8.54	$65.42	$73.96	$1.40	$72.57	$54.42	$1.56
2003	7%	7%	$8.82	$67.59	$76.42	$1.44	$74.97	$56.23	$4.02
2004	14%	24%	$9.12	$69.84	$78.96	$1.49	$77.47	$58.10	$14.12
2005	22%	32%	$9.42	$72.17	$81.60	$1.54	$80.06	$80.06	$25.93
2006	30%	40%	$9.74	$74.63	$84.37	$1.59	$82.78	$82.78	$33.09
2007	36%	46%	$10.08	$77.18	$87.26	$1.65	$85.61	$85.61	$39.57
2008	43%	53%	$10.42	$79.83	$90.25	$1.70	$88.55	$88.55	$46.49
2009	48%	58%	$10.79	$82.62	$93.40	$1.76	$91.64	$91.64	$53.23
2010	54%	64%	$11.16	$85.51	$96.67	$1.82	$94.85	$94.85	$60.37
2011	59%	69%	$11.53	$88.32	$99.85	$1.88	$97.97	$97.97	$67.53
Total			**$99.62**	**$763.12**	**$862.74**	**$16.28**	**$846.46**	**$790.21**	**$345.91**

Enhancement 4: Midair Collisions Accident Data Review

WN-9701/021-02

Safe Flight 21 Program

Midair Collisions
Accident Data Review

13 January 2000

SF21

Outline

- Data Collection
- Background
- Profile of Midair Collisions
- Accident Data
- Open Items

Data Collection

- Previous Studies
  - *Midair Collisions Prompt Recommendations For Improvement of ATC Radar Systems*, Airport Operations, Flight Safety Foundation, Nov-Dec 1999.
  - *1998 Aviation Safety Statistical Handbook*, Office of System Safety (ASY), Federal Aviation Administration.
  - *Collision Avoidance Must Go Beyond "See and Avoid" To "Search and Detect"*, Flight Safety Digest, Flight Safety Foundation, May 1997.
  - *Proposal to Require Traffic Alert and Collision Avoidance Systems (TCAS-II) on Cargo Aircraft*, The Subcommittee on Aviation, Hearing 26 February 1997.
  - *Pamphlet: How To Avoid A Mid Air Collision*, General Aviation Accident Prevention Program, U.S. Department Of Transportation.
  - *Fatal Midair Collision Events*, AirSafe.

- National Transportation Safety Board (NTSB) accident reports: 1983 to 1997

Background

- Development of a viable collision avoidance system for aircraft began as far back as the 1950s but none considered acceptable until the 1980s
  - 1956 - June 30; Collision between two airliners over the Grand Canyon
  - 1978 - September 25; Light aircraft collided with an airliner over San Diego
  - 1981 - FAA decided to proceed with Traffic Alert and Collision Avoidance System (TCAS)
  - 1986 - August 31; Collision involving Aeromexico and a private airplane over Cerritos, California near LAX
  - 1987 - Congress introduced legislation which established deadlines for developing and installing TCAS II
  - 1990 - FAA published a final rule containing the schedule for implementing TCAS II in aircraft with more than 30 passenger seats
  - 1993 - Required implementation of TCAS II was essentially completed

Background (Cont'd)

- TCAS is a family of systems with different levels of capability
  - TCAS I
    - Uses information from transponders installed in other aircraft to provide traffic advisories to the pilot
    - Detects and displays range, approximate bearing, and relative altitude of encroaching aircraft within 4 nautical miles of the host aircraft
    - Does not tell the pilot what to do to avoid a collision
    - Required on small 10 to 30 seat commuter aircraft in 1995
  - TCAS II
    - Uses information from transponders installed in other aircraft to provide traffic advisories and resolution advisories (climb or descend)
    - Provides greater range and bearing accuracy
    - Instructs the crew on how to avoid a collision provided the other aircraft is Mode C or S equipped and is less than 25 seconds from a collision
    - Required on all aircraft with more than 30 passenger seats in 1993

Background (Cont'd)

- TCAS is a family of systems with different levels of capability (cont'd)
  - TCAS III
    - Originally intended to add capability to advise pilots to go left or right, if appropriate, to avoid a collision
    - Work discontinued in 1993 due to developmental problems
  - TCAS IV
    - Under evaluation to determine design approaches
    - Resolution advisories will include horizontal instructions (left or right) in addition to vertical instructions (climb or descend)

- TCAS II software upgrades
  - Expected to reduce unnecessary resolution advisory maneuvers by 25 to 30 percent and double the detection range
  - ADS-B should further reduce the unnecessary resolution advisory actions

Profile Of Midair Collisions

- NTSB study of 105 accidents that occurred from 1964 to 1968
  - Most occupants were on a pleasure flight with no flight plan filed
  - Nearly all occurred in VFR conditions during weekend daylight hours
  - Majority were the result of a faster aircraft overtaking a slower aircraft
  - Majority occurred at uncontrolled airports below 3,000 feet
  - En Route midairs occur below 8,000 feet and within 25 miles of the airport
  - Pilot experience levels ranged from initial solo to 15,000 hours
  - Flight instructors were on-board the aircraft in over one-third of the events

- "Failure of pilot to see other aircraft" cited as a cause in most cases

Accident Data Data Overview

- Midair collisions with at least one jet airliner passenger fatality
  - Includes U.S. and international data
  - 1960 to 1996
- U.S. midair collision accidents
  - Includes both fatal and non-fatal events
  - 1983 to 1997
- U.S. near midair collisions
  - Includes assessment of degree of hazard
  - 1993 to 1998

Accident Data Fatal Jet Airliner Collisions

- 14 fatal jet airliner collisions between 1960 and 1996
  - Over 1,500 total fatalities
  - 7 collisions occurred in the U.S.

#	Date	Location	Airliner Company	Airliner Aircraft	Other Aircraft	Total Fatalities
1	19-May-60	Paris, France	Air Algerie	Caravelle	Small Single Engine	1
2	16-Dec-60	New York, NY	United Air Lines	DC-8	Lockheed Constellation	133
3	09-Mar-67	Urbana, OH	TWA	DC-9-14	Beech Baron	26
4	19-Jul-67	Hendersonville, NC	Piedmont	B-727	Cessna-310	82
5	09-Sep-69	Fairland, IN	Allegheny	DC-9-31	Piper Cherokee	84
6	06-Jun-71	Duarte, CA	Hughes Airwest	DC-9-31	U.S. Navy F-4	50
7	30-Jul-71	Honshu, Japan	All Nippon Airways	B-727-200	Jet Fighter	162
8	05-Mar-73	Nantes, France	Iberia	DC-9-32	Spantax Convair 990	68
9	10-Sep-76	Zagreb, Yugoslavia	Inex Adria	DC-9-32	British Airways Trident 3B	176
10	01-Mar-78	Lagos, Nigeria	Nigeria Airways	F28-1000	Training Aircraft	16
11	25-Sep-78	San Diego, CA	Pacific Southwest	B-727-200	Cessna	150 *
12	31-Aug-86	Cerritos, CA	Aeromexico	DC-9-32	Piper Archer	85 *
13	22-Dec-92	Tripoli, Libya	Libyan Arab Airlines	B-727-200	MiG 23	157
14	12-Nov-96	New Delhi, India	Saudia	B-747-100	Cargo Jet	349

* Includes fatalities on the ground

SF21

Accident Data U.S. Midair Collisions

- 286 U.S. midair collision accidents involving two aircraft between 1983 and 1997
  - Over 90% involve some combination of airplane and helicopter collisions
    - 82% involve airplane to airplane collisions
    - 8% involve helicopter to airplane or helicopter collisions
  - Over 90% involve Part 91 operations
    - 84% involve Part 91 to Part 91 collisions
    - 6% involve Part 91 to Part 135 or Part 129 collisions
    - 5% involve Part 91 to other categories of operation collisions

	Operation Category						
Aircraft Type	Part129/Part91	Part135/Part135	Part135/Part91	Part91/Part91	Part91/Other	Other/Other	**Total**
Airplane/Airplane	1	3	10	202	6	12	**234**
Airplane/Glider	---	---	---	5	---	---	**5**
Airplane/Helicopter	---	1	4	10	2	---	**17**
Airplane/Ultralight	---	---	---	2	2	---	**4**
Balloon/Balloon	---	---	---	7	---	---	**7**
Glider/Glider	---	---	---	9	---	---	**9**
Gyroplane/Ultralight	---	---	---	1	---	---	**1**
Helicopter/Helicopter	---	1	1	4	---	1	**7**
Ultralight/Ultralight	---	---	---	---	---	2	**2**
Total	**1**	**5**	**15**	**240**	**10**	**15**	**286**

* Other consists of Part 103 (ultralights), Part 133 (helicopter with external load), Part 137 (aerial application), and Military

Accident Data U.S. Midair Collisions (Cont'd)

- Most aircraft involved were operating without an ATC clearance
  - Both aircraft were without an ATC clearance in 76% of the events
  - At least one aircraft was without an ATC clearance in 87% of the event

ATC Clearance	ATC Clearance None	VFR	IFR	Other	Unknown	Total
None	217	13	12	5	2	**249**
VFR	---	23	6	0	1	**30**
IFR	---	---	1	0	0	**1**
Other	---	---	---	4	0	**4**
Unknown	---	---	---	---	2	**2**
Total	---	---	---	---	---	**286**

- Majority of midair collisions occur in good visibility conditions
  - 100% occur in VMC
  - 86% occur during daylight with no visibility restrictions

Visibility Restriction	Light Condition Daylight	Dusk	Night	Total
None	247	7	7	**261**
Fog	3	0	0	**3**
Haze	19	1	0	**20**
Unknown	2	0	0	**2**
Total	**271**	**8**	**7**	**286**

Accident Data U.S. Midair Collisions (Cont'd)

- Midair collisions most frequently occur during the approach phase of flight
  - 25% occur with both aircraft on approach
  - 35% occur with at least one aircraft on approach

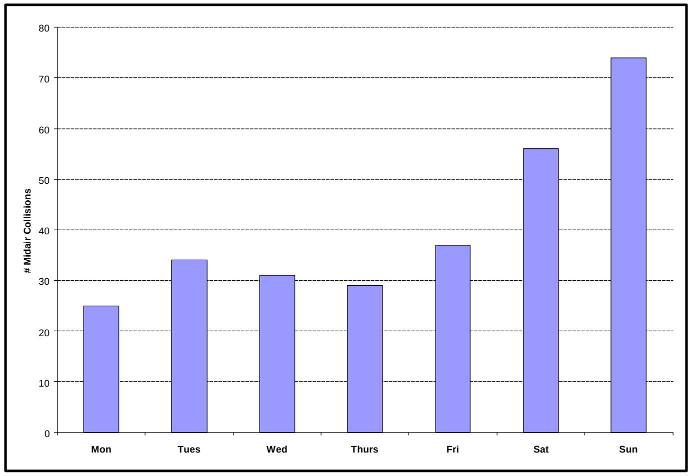
	Both Aircraft		At Least 1 Aircraft	
Flight Phase	**# Accidents**	**% Accidents**	**# Accidents**	**% Accidents**
Standing	0	0%	1	0%
Takeoff	5	2%	23	8%
Climb	6	2%	38	13%
Cruise	49	17%	93	33%
Descent	1	0%	22	8%
Approach	72	25%	100	35%
Landing	14	5%	17	6%
Go-Around	0	0%	3	1%
Maneuvering	47	16%	75	26%
Other/Unknown	2	1%	4	1%

- Midair collisions occur below 5,000 ft in 88% of the accidents for which the information is available

Altitude	# Accidents
Less than 1,000 ft	69
1,000 to 2,000 ft	29
2,000 to 5,000 ft	39
More than 5,000 ft	19
Sub-Total	**156**
Unknown	130
Total	**286**

Accident Data U.S. Midair Collisions (Cont'd)

- 45% of the events occur on either Saturday or Sunday



- Over 50% of the events are located in six states

State	# Accidents	% Accidents
CA	55	19%
FL	23	8%
TX	23	8%
AK	22	8%
WA	14	5%
NY	11	4%
Sub-Total	**148**	**52%**
Other	138	48%
Total	**286**	**100%**

Accident Data U.S. Midair Collisions (Cont'd)

- Both aircraft consist of less than 10 seats for over 95% of the events

Aircraft Type	Number of Seats More Than 30 / Less Than 10	10 to 30 / 10 to 30	10 to 30 / Less Than 10	Less Than 10 / Less Than 10	Total
Airplane/Airplane	3	1	4	226	**234**
Airplane/Glider	---	---	1	4	**5**
Airplane/Helicopter	---	---	2	15	**17**
Airplane/Ultralight	---	---	1	3	**4**
Balloon/Balloon	---	---	---	7	**7**
Glider/Glider	---	---	---	9	**9**
Gyroplane/Ultralight	---	---	---	1	**1**
Helicopter/Helicopter	---	---	---	7	**7**
Ultralight/Ultralight	---	---	---	2	**2**
Total	**3**	**1**	**8**	**274**	**286**

- Focus is on airplane to airplane events for economic valuation
  - Accounts for 82% of the midair collisions
  - Excludes events with helicopters, balloons, gliders, gyroplanes, & ultralights

Operation Category	Number of Seats More Than 30 / Less Than 10	10 to 30 / 10 to 30	10 to 30 / Less Than 10	Less Than 10 / Less Than 10	Total
Part129/Part91	1	---	---	---	**1**
Part135/Part135	---	---	---	3	**3**
Part135/Part91	1	---	3	6	**10**
Part91/Part91	1	1	1	199	**202**
Part91/Other	---	---	---	6	**6**
Other/Other	---	---	---	12	**12**
Total	**3**	**1**	**4**	**226**	**234**

Accident Data U.S. Midair Collisions (Cont'd)

- 446 fatalities associated with the 234 midair collisions involving airplane only

Operation Category	Number of Seats: More Than 30 / Less Than 10	10 to 30 / 10 to 30	10 to 30 / Less Than 10	Less Than 10 / Less Than 10	Total
Part 129/Part 91					
Fatalities	67	---	---	---	**67**
Serious Injuries	0	---	---	---	**0**
Minor injuries	0	---	---	---	**0**
No Injuries	0	---	---	---	**0**
Total	67	---	---	---	**67**
Part 135/Part 135					
Fatalities	---	---	---	2	**2**
Serious Injuries	---	---	---	0	**0**
Minor injuries	---	---	---	0	**0**
No Injuries	---	---	---	12	**12**
Total	---	---	---	14	**14**
Part 135/Part 91					
Fatalities	2	---	27	6	**35**
Serious Injuries	0	---	0	1	**1**
Minor injuries	0	---	0	0	**0**
No Injuries	7	---	11	26	**44**
Total	9	---	38	33	**80**
Part 91/Part 91					
Fatalities	0	0	5	312	**317**
Serious Injuries	0	0	0	38	**38**
Minor injuries	0	0	0	53	**53**
No Injuries	4	3	0	307	**314**
Total	4	3	5	710	**722**
Part 91/Other					
Fatalities	---	---	---	14	**14**
Serious Injuries	---	---	---	2	**2**
Minor injuries	---	---	---	1	**1**
No Injuries	---	---	---	8	**8**
Total	---	---	---	25	**25**
Other/Other					
Fatalities	---	---	---	11	**11**
Serious Injuries	---	---	---	6	**6**
Minor injuries	---	---	---	2	**2**
No Injuries	---	---	---	6	**6**
Total	---	---	---	25	**25**
All					
Fatalities	69	0	32	345	**446**
Serious Injuries	0	0	0	47	**47**
Minor injuries	0	0	0	56	**56**
No Injuries	11	3	11	359	**384**
Total	80	3	43	807	**933**

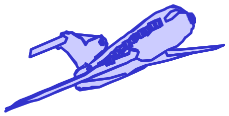
* Does not include fatalities or injuries suffered on the ground

Accident Data U.S. Midair Collisions (Cont'd)

- 85% of the aircraft in the 234 midair collisions involving airplane only were either destroyed or substantially damaged

Operation	Number of Seats				
Category	More Than 30 / Less Than 10	10 to 30 / 10 to 30	10 to 30 / Less Than 10	Less Than 10 / Less Than 10	**Total**
Part 129/Part 91					
Air Carrier - Destroyed	1	---	---	---	**1**
Air Carrier - Substantial	0	---	---	---	**0**
GenAvn - Destroyed	1	---	---	---	**1**
GenAvn - Substantial	0	---	---	---	**0**
Part 135/Part 135					
Air Taxi - Destroyed	---	---	---	2	**2**
Air Taxi - Substantial	---	---	---	2	**2**
Part 135/Part 91					
Air Taxi - Destroyed	0	---	2	1	**3**
Air Taxi - Substantial	1	---	1	2	**4**
GenAvn - Destroyed	1	---	2	2	**5**
GenAvn - Substantial	0	---	1	4	**5**
Part 91/Part 91					
GenAvn - Destroyed	0	0	2	190	**192**
GenAvn - Substantial	2	1	0	149	**152**
Part 91/Other					
GenAvn - Destroyed	---	---	---	6	**6**
GenAvn - Substantial	---	---	---	2	**2**
Military - Destroyed	---	---	---	2	**2**
Military - Substantial	---	---	---	1	**1**
Other/Other					
GenAvn - Destroyed	---	---	---	16	**16**
GenAvn - Substantial	---	---	---	5	**5**
Military - Destroyed	---	---	---	1	**1**
Military - Substantial	---	---	---	0	**0**
All					
Destroyed	3	0	6	220	**229**
Substantial	3	1	2	165	**171**

Accident Data U.S. Midair Collisions (Cont'd)



- 15.6 average annual midair collisions involving airplane only totaling $97M in costs

Operation Category	Number of Seats: More Than 30 / Less Than 10	10 to 30 / 10 to 30	10 to 30 / Less Than 10	Less Than 10 / Less Than 10	Total	Annual Average
Part 129/Part 91						
Personal Injury	$180.90	---	---	---	**$180.90**	**$12.06**
Aircraft Damage	$20.00	---	---	---	**$20.00**	**$1.33**
Total Accident Cost	$200.90	---	---	---	**$200.90**	**$13.39**
Number of Accidents	1	---	---	---	**1**	**0.07**
Average Accident Cost	$200.90	---	---	---	**$200.90**	**$200.90**
Part 135/Part 135						
Personal Injury	---	---	---	$5.40	**$5.40**	**$0.36**
Aircraft Damage	---	---	---	$1.62	**$1.62**	**$0.11**
Total Accident Cost	---	---	---	$7.02	**$7.02**	**$0.47**
Number of Accidents	---	---	---	3	**3**	**0.20**
Average Accident Cost	---	---	---	$2.34	**$2.34**	**$2.34**
Part 135/Part 91						
Personal Injury	$5.40	---	$72.90	$16.72	**$95.02**	**$6.33**
Aircraft Damage	$0.67	---	$2.65	$2.53	**$5.84**	**$0.39**
Total Accident Cost	$6.07	---	$75.55	$19.25	**$100.86**	**$6.72**
Number of Accidents	1	---	3	6	**10**	**0.67**
Average Accident Cost	$6.07	---	$25.18	$3.21	**$10.09**	**$10.09**
Part 91/Part 91						
Personal Injury	$0.00	$0.00	$13.50	$864.27	**$877.77**	**$58.52**
Aircraft Damage	$0.27	$0.13	$1.04	$119.00	**$120.44**	**$8.03**
Total Accident Cost	$0.27	$0.13	$14.54	$983.27	**$998.21**	**$66.55**
Number of Accidents	1	1	1	199	**202**	**13.47**
Average Accident Cost	$0.27	$0.13	$14.54	$4.94	**$4.94**	**$4.94**
Part 91/Other						
Personal Injury	---	---	---	$38.88	**$38.88**	**$2.59**
Aircraft Damage	---	---	---	$49.52	**$49.52**	**$3.30**
Total Accident Cost	---	---	---	$88.40	**$88.40**	**$5.89**
Number of Accidents	---	---	---	6	**6**	**0.40**
Average Accident Cost	---	---	---	$14.73	**$14.73**	**$14.73**
Other/Other						
Personal Injury	---	---	---	$32.91	**$32.91**	**$2.19**
Aircraft Damage	---	---	---	$30.62	**$30.62**	**$2.04**
Total Accident Cost	---	---	---	$63.52	**$63.52**	**$4.23**
Number of Accidents	---	---	---	12	**12**	**0.80**
Average Accident Cost	---	---	---	$5.29	**$5.29**	**$5.29**
All						
Personal Injury	$186.30	$0.00	$86.40	$958.18	**$1,230.88**	**$82.06**
Aircraft Damage	$20.93	$0.13	$3.69	$203.28	**$228.04**	**$15.20**
Total Accident Cost	$207.23	$0.13	$90.09	$1,161.46	**$1,458.92**	**$97.26**
Number of Accidents	3	1	4	226	**234**	**15.60**
Average Accident Cost	$69.08	$0.13	$22.52	$5.14	**$6.23**	**$6.23**
Average Annual						
Personal Injury	$12.42	$0.00	$5.76	$63.88	**$82.06**	
Aircraft Damage	$1.40	$0.01	$0.25	$13.55	**$15.20**	
Total Accident Cost	$13.82	$0.01	$6.01	$77.43	**$97.26**	
Number of Accidents	0.20	0.07	0.27	15.07	**15.60**	
Average Accident Cost	$69.08	$0.13	$22.52	$5.14	**$6.23**	

* Does not include fatalities or injuries suffered on the ground

Accident Data U.S. Near Midair Collisions

- 1,404 near midair collisions between 1993 and 1998
  - 45% were reported by commercial operators
  - Over 10% were determined to involve a critical degree of hazard

Reporting Operator	1993	1994	1995	1996	1997	1998	Total	Percentage
Air Carrier	66	81	60	60	95	76	438	31.2%
Commuter	26	27	25	10	13	7	108	7.7%
Air Taxi	11	22	19	12	13	11	88	6.3%
General Aviation	72	90	74	72	77	68	453	32.3%
Military	70	51	50	35	29	37	272	19.4%
Other	9	4	10	5	9	8	45	3.2%
Total	254	275	238	194	236	207	1,404	100.0%

Degree of Hazard	1993	1994	1995	1996	1997	1998	Total	Percentage
Critical	35	47	32	26	31	19	190	13.5%
Potential	158	139	139	101	105	74	716	51.0%
No Hazard	61	71	63	55	70	41	361	25.7%
Open (Investigation Underway)	0	18	4	12	30	73	137	9.8%
Total	254	275	238	194	236	207	1,404	100.0%

Open Items

- Safe Flight 21 benefits pool
  - TCAS claims
  - Transponder equipage
    - Not available in NTSB reports
    - Available in near midair reports
    - Overall GA population data
  - Exposure metric (operations vs. flight hours) used to derive accident rate
  - Scope (Alaska vs. NAS)

- Effectiveness estimate
  - Case study analysis
  - Previous studies (i.e. TCAS)
  - Other

Enhancement 6: Efficiency Benefits Surface Surveillance and Navigation for the Pilot

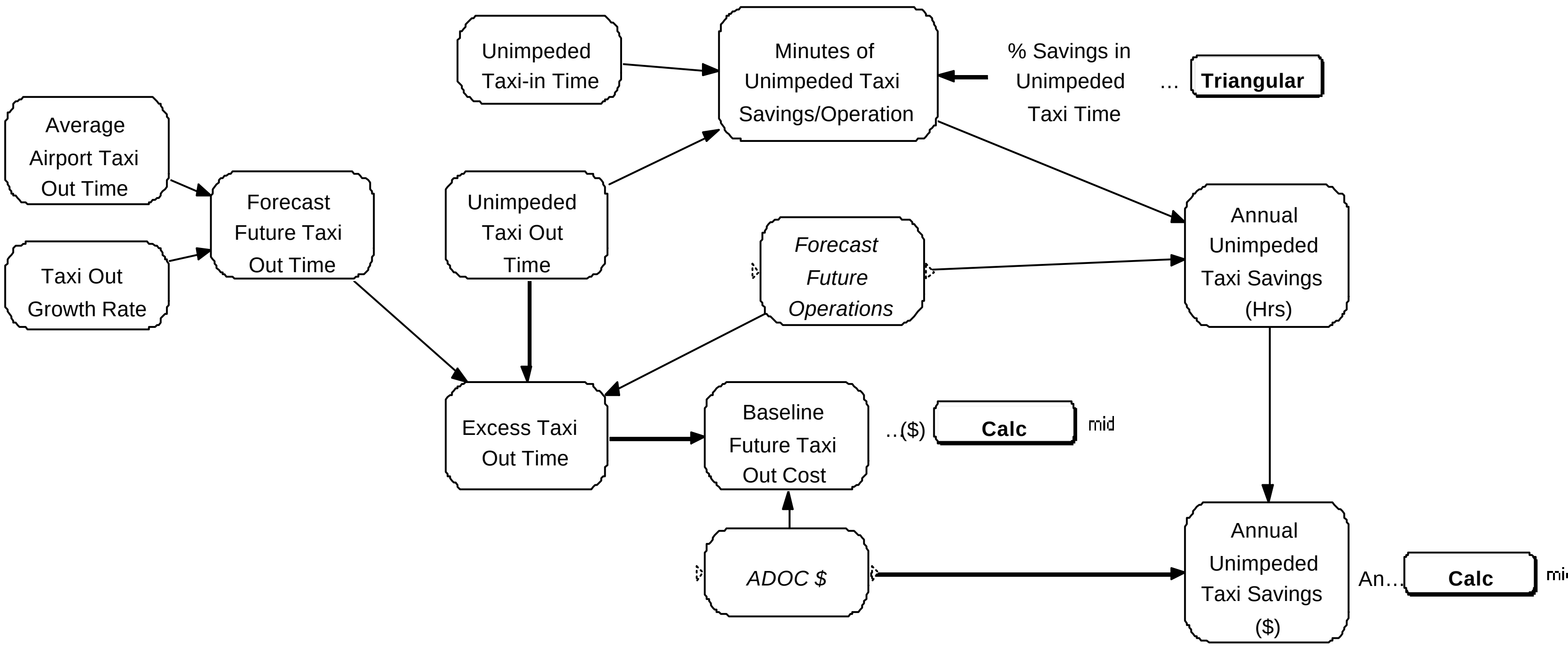
Efficiency Benefits

- ASDE IIII Study (FAA/APO 1993)
  - ➢ Conditions for ***relevant*** operations
    - ∗ Very Low Visibility: CAT II & CAT III
    - ∗ Reduced Visibility: CAT I
    - ∗ Condition of light: VFR night (night /glare)
- What is the key impact on the SF21 Surface Enhancement Analysis?
  - ➢ Number of operations under consideration (VFR night)
- The SF21 Benefits Subgroup determined that efficiencies associated with improved information to the cockpit may occur in any conditions of light

Phase I Analysis - Refined Estimate

- Captures the impact of the queueing effect on taxi-out times
  - Key drivers
    - Demand
    - Capacity

Enhancement 6 - Efficiency Relationship Tree



SF21

Preliminary Results

Efficiency Assumptions - Enhancement 6

Efficiency:

- ADS-B with moving map display in the cockpit is expected to render taxi-time improvements
  - Improved surface navigation from the gate to departure runway, or from the arrival runway to the arrival taxiway is assumed to reduce <u>unimpeded</u> taxi-times by 5 % for those operations that do not experience taxi-queueing delay
  - Unimpeded taxi-out time is defined as the taxi-out time under optimal operating conditions
    - It is measured as:
      - Bottom 15th percentile of taxi-out time for busy airports
      - 50th percentile of taxi-out time of all other sites
  - It is assumed that the best-quartile of taxi-times cannot be improved

Efficiency: Enhancement 6

- Benefits pool is calculated as a function of:
  - Normally distributed taxi times
  - Unimpeded taxi times
  - Number of operations
- NAS-Wide operations considered:
  - 56% of arrivals do not experience taxi-in delays
  - 40% of departures do not experience taxi-out delays
- LD operations considered:
  - 59% (MEM), 64% (SDF) of arrivals do not experience taxi-in delays
  - 39% (MEM), 39% (SDF) of departures do not experience taxi-out delays
- Effectiveness is estimated at 5%

Efficiency Benefits (2002-2011)

	Constant $M	LD: ORV	NAS*
	Benefits Pool	$ 210	$ 10,894
Minus	Existing/Planned Capabilities	$ -	$ -
Equal	Remaining Pool	$ 210	$ 10,894
	Effectiveness	$ 10	$ 545
	Equipage Factor	$ 7	$ 337

*** NAS = Towered Airports only**

Enhancements 6 & 7: Safety Benefits
Surface Surveillance and Navigation for the Pilot and Surface Surveillance for the Controller

Enhancement 6 &7 Safety Benefits Background

- The SF21 Benefits Team considered Surface /Approach Operations and Airport Surface Display to the Controller (Enhancements 6 &7) to have common safety relationships in the terminal area and proposed merging them for this CBA to the SF21 Select Committee. The committee approved combining the benefits analysis of Enhancements 6 & 7.

- In addition to combining Enhancements 6 & 7, the methodology accounts for the impacts of existing and planned capabilities (such as RIRP) on surface safety.

- The Runway Incursion Reduction Program (RIRP) Analysis Team completed a thorough assessment of runway accidents in the NAS. Based on the site-by-site findings of this work, the benefits pool for MEM, ILN and SDF as well as the NAS-wide runway safety pool were derived.

- The SF21 benefits team also completed an assessment of surface accidents not included in the scope of the Runway Incursion Program. These accidents occurred on the surface airport, but off the runway, and involved at least one aircraft. The forecasted savings for avoided non-runway surface accidents translated into $40M for the NAS over the relevant 10-year period.

Safety Assumptions - Enhancements 6 & 7

Effectiveness:

- It is assumed that SF21and RIRP Phase II share the remaining (unclaimed) surface benefits pool
- Investment decision JRC to approve ASDE-X quantities is expected in Summer 2000. This may impact the benefit estimates for SF21 surface safety enhancements. Phase II RIRP (distinct from ASDE-X) to be identified and confirmed by ATS-20

ASDE/ASDE-X Sites (95%)

- Existing/Planned capabilities (85%)
  - ASDE + AMASS/ASDE-X are assumed to be 75% effective based on existing studies: RIRP, APO ASDE Study, MIT Lincoln Labs Study
  - RIRP 2 is assumed to have a 10% incremental effectiveness over and above ASDE/ASDE-X*
- CDTI in the cockpit is assumed to have a 10% incremental effectiveness over and above existing ASDE/ASDE-X systems

* RIRP II is ***not*** considered in Limited Deployment

Safety Assumptions - Enhancement 6 & 7

Non-ASDE/ASDE-X Sites (95%)

- RIRP II is assumed to have 47.5% effectiveness
- Combined effectiveness of ADS-B to the controller and the pilot is assumed to have 47.5% effectiveness

Effectiveness Summary

LD

$$\text{Effectiveness} = 0.2\,(BP_{\text{ASDE/ASDE-X}}) + 0.95(BP_{\text{Non-ASDE/ASDE-X}})$$

NAS

$$\text{Effectiveness} = 0.5[\,0.2\,(BP_{\text{ASDE/ASDE-X}}) + 0.95(BP_{\text{Non-ASDE/ASDE-X}})]$$

BP = Benefits Pool

Safety: Enhancements 6 & 7 Results

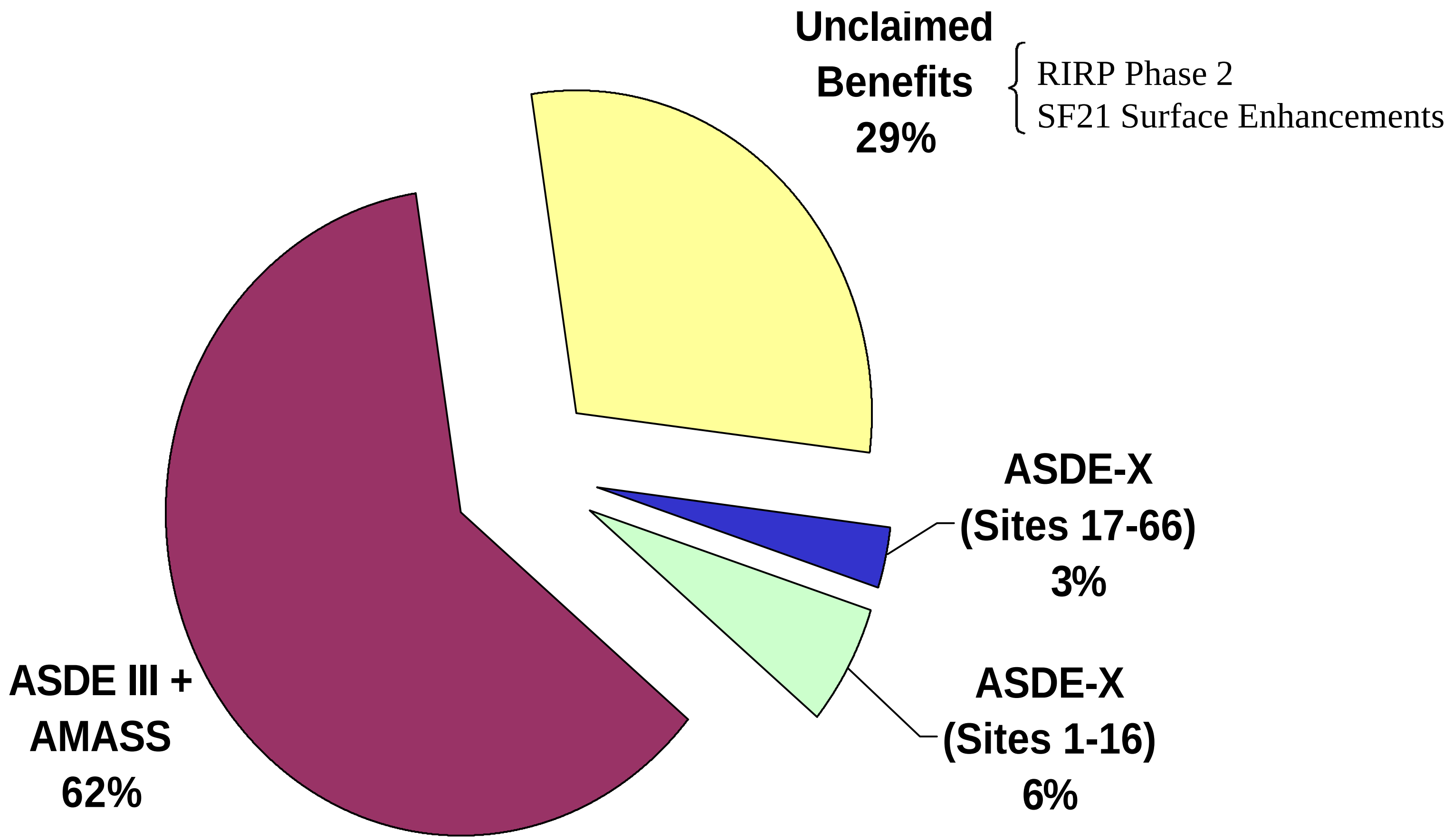
- It is assumed that SF21 and RIRP Phase II share the remaining (unclaimed) surface benefits pool
- A programmatic allocation of 50% to each program is used to calculate benefits for NAS
- No programmatic allocation is assumed for LD

Surface Safety Benefits (2002-2011)

	Constant $M	LD: ORV	NAS *
	Benefits Pool	$ 9.0	$ 1,047
Minus	Existing/Planned Capabilities (ASDE/ASDE-X/RIRP 2)	$ 6.5	$ 867
Equal	Remaining Pool	$ 2.5	$ 180
	Effectiveness	$ 2.0	$ 127
	Equipage Factor	$ 1.5	$ 85

*** NAS = Towered Airports only**

Surface Safety Benefits Pool



Surface Safety Benefits Decomposition

Constant $M

Towered Sites	System Benefits	Unclaimed Benefits	Total Benefits
ASDE + AMASS (34 sites)	$ 627.4	$ 209.2	$ 836.6
ASDE-X (sites 1- 16)	$ 61.7	$ 41.7	$ 103.4
ASDE-X (sites 17 - 66)	$ 31.4	$ 22.6	$ 54.0
All Other	$ -	$ 27.1	$ 27.1
Total	**$ 720.5**	**$ 300.6** ✪	**$ 1,021.1**

✪ Does not include $8.2Million **on runway** accidents, and $32.6 Million estimated for ***Off-Runway Accidents***

SF21

Preliminary Results

Runway Accidents

- Of the 20 Runway Accidents
  - 7 were included in the Runway Incursion Study
    - Involved 7 Air Carrier Aircraft, 2 Air Taxi, 4 General Aviation, 1 Ground Vehicle
    - 45 Fatalities, 24 Serious Injuries, 43 Minor Injuries
    - 5 Aircraft Destroyed, 6 Substantially Damaged Aircraft
  - Estimated Total Cost of accidents $160 Million
- Of the 13 Remaining Runway Accidents
  - Not Included in the Runway Incursion Study
    - Only General Aviation aircraft Involved
    - 1 Fatality, 4 Serious Injuries, 1 Minor Injuries
    - 4 Aircraft Destroyed, 21 Substantially Damaged Aircraft
  - Estimated Total Costs of Accidents $8.2 Million

Surface Accidents (Off-Runway)

- The analysis evaluated 107 off-runway accidents
  - 20 AC, 9 AT, 122 GA aircraft Involved
  - No Fatalities, 6 Serious Injuries, 26 Minor Injuries
  - 1 Aircraft Destroyed, 130 Substantially Damaged Aircraft
  - Estimated Total Costs of Accidents $32.6 Million

Benefit Forecast - (Off-Runway Surface Accidents)

- Used 10-Year Average rate (by operations) for off-runway accidents only (Runway Accidents to be forecasted separately)
- Forecast for 10-year period 2002-2011
  - Totals
    - Aircraft Restoration Costs - $39 Million
    - Personnel Costs - $1.3 Million
    - Number of Accidents - 133